Prof. D. C. Eaton
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M. H. [illegible]

DEPARTMENT OF AGRICULTURE,

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LETTERS ON THE DISEASES OF PLANTS:

BY

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Letters on the Diseases of Plants.

(With nearly One Hundred Illustrations.*)

BY N. A. COBB.

THE following notes are compiled from some of my official letters written during the last six months, in answer to inquiries directed to the Department of Agriculture from various parts of Australia. Though most of them relate to pests found doing damage to crops, a number are miscellaneous.

I. WHEAT AND MAIZE, AND SOME OF THEIR DISEASES.

No inquiries are more numerous than those relating to wheat, outnumbering any others as they do in the ratio of four or five to one. Most of these inquiries are concerning the names and qualities of samples of wheat. No doubt this is due to the fact that the shortage in the last two Australian crops has caused the importation of large quantities of wheat from Canada and California. Having used such wheat for seed, and thus secured novel varieties, growers have sent samples by the score. In a number of cases these samples have been unsatisfactory for reasons that I wish to explain in full, so that correspondents may in future be a little more considerate.

The naming of a variety of wheat from a sample is, even under the best conditions, a task that few will undertake. The reason for this is, that the number of known varieties is very great,—how great may be best judged from the following list of wheats now growing in the Nomenclature Plots of this Department located at Wagga and Bathurst:—

LIST of VARIETIES of WHEAT arranged in Groups:—

I. Durum and Poulard Group.

1 Egyptian E.
2 Sicilian Baart.
3 Forella.
4 Mica.
5 Medeah.
6 Egyptian C 1.
7 ,, C 2.
8 ,, D.
9 ,, A 1.
10 ,, A 2.
11 Young's Bearded.
12 Paros.
13 Atlanti.
14 Banater.
15 Cretan.
16 Belotourka.
17 Missogen.
18 Bearded Club.
19 Pugh's R. R.
20 Salvator.
21 Hebron.
22 Hunter's White.
23 Algerian.
24 White-eared Mummy.
25 Brown-eared Mummy.
26 Egyptian B.
27 ,, F.
28 Australian Poulard.
29 Bancroft.
30 Egyptian H.
31 Laidley.

II. Poland Group.

32 Poland.

III. Amidonnier Group.

33 Blue Heron.

IV. Bailey Group.

34 Bailey.

V. Rieti or Ladoga Group.

35 Roberts.
36 Rural New Yorker Rye Wheat Hybrid.
37 Diche Mediterranean.
38 Ladoga.

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* Most of the illustrations were prepared by the author, and all were produced under his immediate direction. Figures 13, 14, 15, 16, 17, 18, 39, 40, 41, 42, 43, 44, 45, 46, 49, 50, 51, 52, 53, and 54 were drawn on the wood by the author. Figures 2, 11, 12, 19, 23, 27, 28, 29, 34, and 38 are the author's photographs. Of the remaining figures, Nos. 1, 4, 5, 7, 20, 21, 22, 24, 25, 26, 30, 31, 32, 33, 35, 36, 37, 47, 56, 57, 58, and 59 were prepared by Mr. E. M. Grosse; Nos. 3, 6, and 8 by Mr. W. E. Chambers (who did all the engraving); No. 55 by Mr. F. C. Wills; and No. 48 by Mrs. N. A. Cobb.

39 Hindustan.
40 Tasmanian Red.
41 Lehigh.
42 Brogan's Red and White.
43 Gharaf.
44 Anglo-Australian.
45 Ironclad.
46 Rieti.
47 Ultuna Red Beard.
48 Bearded Red Autumn.
49 Champlain.

VI. Australian Bearded Group.

50 Australian Bearded, Port Germain.

VII. Japanese Group.

51 Fl.
52 Early Japanese.

VIII. Bearded Hérisson Group.

53 Sherman.
54 Bearded Hérisson.

IX. Winter Nigger Group.

55 Winter Nigger.
56 Rudy.
57 Bearded Champion.

X. Lazistan Group.

58 Lazistan.
59 Reliable.
60 Penguin Island.
61 Pringle's No. 5.
62 Russian (Shelton's).
63 Frumente Ferrareuse.
64 Bearded Monarch.
65 Thuiss.
66 Deitz.
67 Fulcaster.
68 Miami Valley.
69 New Red Wonder.
70 Crate.
71 Jaspar.
72 Saratow.
73 Rio Grande.
74 Mediterranean.
75 Australian Amber.
76 Soft Portugese.
77 Darblay's Hungarian.
78 Andriola Amber.
79 Barbu à Gros Grain.
80 China Tea.

XI. Beal Group.

81 Beal.

XII. Early Baart Group.

82 Early Baart.
83 Dutoits.
84 Quartz.
85 Early Bearded (French).
86 African.
87 Archer's Prolific.
88 Johnson.
89 Democrat.
90 Champlain Hybrid.
91 Uncle Tommy.
92 Soft Algerian.
93 Californian Genesee.
94 Tall Bearded Neapolitan.
95 Cythere White.

XIII. Bearded Indian Group.

96 Canning Downs.
97 Gore's Indian No. 2.
98 ,, No. 1.
99 Indian Club.

XIV. Bearded Velvet Group.

100 Bearded Velvet.
101 Andros.
102 Pride of Butte.
103 Cone Rivet.

XV. White Velvet Group.

104 Velvet Chaff Red Grain.
105 Old French Velvet.
106 White Velvet.
107 Carter's 87.
108 ,, F.
109 Tardent's Blue.
110 Carter's D.
111 Canadian Velvet Chaff.
112 Brigg's R. R.
113 Jones' Winter Fife.
114 Velvet New Zealand.
115 Basalt.
116 Langfeldt's.

XVI. Velvet Pearl Group.

117 Velvet Pearl.
118 Indian Fife.
119 Carter's 43.
120 Rye Wheat.

XVII. Indian Group.

121 Indian Early.
122 ,, Delta.
123 ,, Zeta.
124 Carter's 81.
125 Early Para.
126 King's Jubilee.

XVIII. Steinwedel Group.

127 Pride of Barossa.
128 Steinwedel.

XIX. Purple Straw Group.

129 Rattling Jack.
130 Fountain.
131 The Blount.
132 Northern Champion.
133 Italian Tuscan Purple Straw.
134 Farmer's Friend.
135 Fillbag.
136 Rattling Tom.
137 Red Straw.
138 Hudson's Early Purple Straw.
139 Jacinth.
140 Australian Glory.
141 Steer's Early Purple Straw.

XX. Tuscan Group.

142 Battlefield.
143 White Tuscan.
144 Frame's Early.
145 Red Tuscan.
146 Purple Straw Tuscan.
147 Californian Chili.
148 Oakshott's Champion.
149 Blue Stem.
150 District.
151 Agate.
152 American Purple Straw.
153 Carter's E.
154 Carter's B.

XXI. Lammas Group.

155 Bordier.
156 Hunter's White.
157 White Tuscan of Lake Bathurst.
158 White Naples.
159 White Flanders.
160 Chiddam.
161 White Lammas.
162 Landreth's Hard Winter.
163 Green Mountain.
164 Dallas.
165 Leak's R. R.
166 White Lammas (from Young
167 Australian Talavera.
168 Snowball.
169 Talavera de Bellevue.
170 Zealand.
171 Mammoth,
172 Carter's 103.
173 Pringle's Vermont.
174 Prope.
175 Chrysolite.

XXII. Essex Group.

176 Port McDonald.
177 White Essex.
178 Tuscan Essex.
179 Frampton.
180 Chiddam's White Spring
181 Martin's Amber.
182 Soft Algerian.
183 Gneiss.

XXIII. White Club Group.

184 Schilf.
185 Fort Collins.
186 Oregon Big White Club.
187 Hedgerow.
188 Little Club.

XXIV. Noé Group.

189 Zimmerman.
190 Sardius.
191 Summer Club.
192 High Grade.
193 Manitoba.
194 Long Berry.
195 Prince Edward Island.
196 German Beardless March.
197 Mouton.
198 China Spring.
199 Buckby's R.R.
200 Blount's Fife.
201 Urtoba.
202 Pictet.
203 Red Nott.
204 Blount's R.R.
205 Fultz.
206 Noé.
207 Crépi.
208 Bladette Paylaureuse.
209 Saumur de Mars.
210 North Carolina.
211 Autumn Saumur.

XXV. Fife Group.

212 Small's O.K.
213 Anderson's R.R.
214 King's R.R.
215 Niagara.
216 Sorrel.
217 White Chaff Red.
218 Improved Rice.
219 Scotch Red.
220 Russian.
221 Ontario Wonder.
222 Smooth Red Spring.
223 Saskatchewan Fife.
224 Scotch Fife.
225 Finley.
226 Inglis' R.R.
227 Count Waldersdorff.
228 Nimitybelle.
229 Canada Club.
230 Carter's B.
231 Amethyst.
232 Gallician Saumur.
233 Dominion.
234 Red Lorrain.
235 Sardonyx.
236 Kaiser.
237 Sapphire.
238 Indian Gamma.
239 ,, D.

240 Webb's Challenge.
241 Eclipse.
242 Hornblende.
243 Jock.
244 Porcelain.
245 Trap.
246 Ruby.
247 Wright's R.R.
248 Feldspar.
249 White Russian.
250 White Fife.
251 Adamant.
252 Fluorspar.
253 Improved Fife.

XXVI. Defiance Group.

254 Clark's R.R.
255 Beryl.
256 Pringle's No. 5.
257 Australian R.R.
258 Thomas' R.R.
259 Leak's Defiance.
260 Pringle's Defiance.
261 Russian.
262 Pearl or Velvet.
263 Murray River.
564 Defiance.
265 Bega.
266 1 A1
267 Little Wonder.
268 Inglis' Success.
269 Blount's Lambrigg.

XXVII. Golden Drop Group.

270 Trump.
271 Carter's K.
772 ,, H.
223 ,, 107.
274 Pringle's No. 6.
275 Opal.
276 Hallett's Pedigree.
277 Goldsmith's Pedigree.
278 Carter's New Hybrid.
279 Golden Drop.

XXVIII. Square Head Group.

280 Berseler's Club.
281 Scholey's Square Head.
282 Bestehorn's Dividend.
283 Emerald.
284 Red Altkirche.
285 Majorica carusa.
286 Webb's King Red.
287 Carter's A.
288 ,, C.
289 Dwarf Humboldt's.
290 Blé à épi carré.
291 Red Chaff Square Head.
292 Sicilian Square Headed Red.
293 Four-rowed Sheriff.
294 Rimpau.
295 Carter's G.
296 Mould's Red.

XXIX. Allora Spring Group.

297 Clubbed Indian.
298 Indian Alpha.
299 Budd's Early.
300 Allora Spring.
301 Odessa sans barbes.

XXX. Ward's Prolific Group.

302 Golden Prolific.
393 Australian Wonder.
304 Marshall's No. 3.
305 Marshall's No. 8.
306 ,, No. 10.
307 ,, No. 2.
308 Ward's Prolific.
309 Hercules.
310 Red Clawson.
311 Ward's White.
312 Marshall's No. 5.
313 Rousselin.
314 Robins R.R.
315 Currell.

XXXI. Red Provence Group.

316 Odessa.
317 Red Bordeaux.
318 Pool.
319 Clawson.
320 Prince Albert.
321 Red Province.
322 Willett's.
323 Spaulding's Prolific.
324 Banham's Browick.
325 Red Russian.
326 M'Ghee's White.

XXXII. Rural New Yorker Group

327 Rural New Yorker.

XXXIII. Rye Wheat Group.

328 German Emperor.
329 Rye Wheat.
330 Early Genesee.
331 Stewart.
332 Rye Wheat (for grain).

Miscellaneous.

333 Tuscan Island.

When the reader has examined the foregoing list, he will very likely wonder at its length, and no doubt ask, "Is it possible that there are so many distinct varieties of wheat?" To which the ready answer is, "Yes, it is true; there are more than three hundred varieties of wheat." I do not mean to imply that every name in the foregoing list represents a distinct variety, for it is beyond question that a number of these so-called varieties, especially in the Purple Straw, Lammas, Fife, and Defiance groups, are identical. These are kept in our plots only out of deference to well-known popular names.

One moment more and we will return to the subject of naming wheats. I only wish, first, to explain the nature of the nomenclature plots, which have now become such an established institution. Rows of wheat, each row containing only a single sort, are sown side by side in the order given in the above list. Each row is plainly labelled, and all the wheats of a kind (that is, closely related to each other) are gathered together into a plot, as shown in the illustration Fig. 2, p. 7, and the plot is labelled by means of a large sign bearing the name of the group or family.

These wheats are the result of six years of careful study and selection. They have been chosen from over 1,000 samples obtained from all parts of the world—Australia, New Zealand, United States, Great Britain, Russia, India, Japan, China, South Africa, Italy, Spain, France, Germany, Hungary, Turkey, Algiers, Mexico, Chili, and Canada. The whole world has been drawn upon for these samples.

Hundreds of farmers visit these plots annually, and are invariably found ready to admit their value in educating the community up to a better knowledge of the names of varieties of wheat. These plots and the stud-plots mentioned on a later page have arisen out of my investigation into the

disease known as wheat-rust, and are but part of the machinery being created to cope with that disease, though this fact will, probably, for some years yet to come, fail to be fully appreciated.

Now, as to the naming of samples of wheat. Is it any wonder, when the number of varieties is so great, that even experts shrink from committing themselves as to the name of a wheat, unless they have the best of samples and all the information that is available? Those who bring or send samples of wheat to be named should, if possible, provide a *full-grown ripe stool or plant*. In addition, they should give all the information they possess, such as answers to the following questions:—

1. Is the variety early, mid-season, or late?
2. Where did it come from originally—*i.e.*, what is its history?
3. What names have you heard applied to it?
4. Where was the specimen grown, and on what kind of soil?
5. Is the specimen well grown, or have you reason to suppose it to be smaller or larger than usual?

The answers to these and similar questions are always of assistance in determining the name of the variety. To some it may seem a trivial matter, this naming of wheats. Stop one moment and consider the magnitude of the operations in wheat, and then think what a difference it makes whether one variety is a trifle better than another for a given locality or purpose. There you have the reason for these numerous inquiries concerning the names of wheat. Each variety has its particular qualities which suit it to particular purposes, and this is the explanation of the large number of varieties, and of the fact that as many as fifty varieties are grown on an extensive scale.

1. Velvet Pearl.

Of these numerous varieties of wheat none have this season excited greater interest than those which have been recently imported from the United States. I observe that the variety that has excited the greatest amount of interest and curiosity is that variously known as Velvet Pearl, Red Californian, Californian March, &c. Of these various names the one to be preferred is Velvet Pearl. This variety may be described as follows:—It is of medium height, and has a rather shiny, yellow, fine, semi-solid straw, possessing all the good qualities in a medium degree. When ripening the straw is yellow, never purple. The sheath of the upper leaf is less than half as long as the distance from the uppermost joint to the ear. The ears are red and velvety, and this together with the bright yellow straw, gives the plants a particularly bright and attractive look. The ears are beardless, of medium length, very regular, compact, somewhat tapering, square, erect or leaning, straight, or slightly curved, acute at the tip, abrupt at the base, where there are two or three sterile spikelets. The fertile spikelets are spread out wide like an open fan, and contain three or four grains. The dull and streaky chaff is of medium length, acute and short-awned throughout the length of the ear, rather deep, roundbacked, of medium

Fig. 1.—Ear of Velvet Pearl one-third full size. Grains full size.

stiffness, but rather loosely attached and not lying close to the grain, so that shelling is likely to occur unless the harvesting is well-timed and careful. The grain is very small, short, very plump, opaque, whitish,

Fig. 2.—Photograph of a small portion of the nomenclature plot as planted at the Wagga and the Bathurst Experiment Farms. Each row of wheat is of a different sort, its name being painted on a 3-inch by 5-inch metal sign placed at the end of the row. These small signs may be seen through the wire netting. These varieties of wheat, each consisting of a single row, are gathered into groups. Nearly the whole of the varieties, fourteen in number, belonging to the Ward's Prolific Group (see page 210) are shown in the picture. Nearly the whole of the Red Provence Group (see page 210) is also shown. The groups are separated from each other by paths. The stacks at the back are a portion of the 1896 seed-wheat—each stack a different sort. The extensive paddocks this side of the far-distant trees are among those on which seed wheat is raised.

flat-bosomed, blunt at both ends, with a shallow close crease and a comparatively abundant brush. A back-crease sometimes is visible. When cut with a knife the interior of the grain shows up very floury. The germ-sculpture is large—that is, two-fifths as long as the grain.

Velvet Pearl is a very early wheat, giving a grain of very good milling quality from the Australian point of view, but it is only a fairly good yielder, as it stools rather sparingly in an upright manner. It will stand a dry climate, in fact seems particularly suited to such. Although the stools are small, this is easily compensated for by thicker sowing. The bulk of seed per acre is about the same as for other varieties, the seed being small. The wheats of which this is an example seem to have come into favour in but few parts of the world. The variety known as Red Californian, with velvet chaff, appears to be identical with the present; both resemble Allora Spring, but the latter has not velvet chaff. New Zealand Velvet appears to be the same as Velvet Pearl. A wheat known as Mexican or Red Mexican is identical with this. Velvet Pearl is early—early enough, perhaps, to be called rust-escaping. It is identical with Blé de Mars de Californie of France. A considerable quantity of it is grown in South Australia.

Fig. 3.—Grain of Velvet Pearl, average form and size.

Prominent characteristics.—Medium height, short, bald, velvety, red heads, smallish white grain of only fairly good quality, very early, fairly good yielder, liable to shell.

Velvet Pearl is, it appears, extensively grown in California and Mexico, and was imported largely last year from the former place to make up the local deficiency, and thus naturally found its way into cultivation. As a milling sort it cannot be said to stand very high. It is early and fairly prolific, but has a rather weak straw, and is very liable to rust. It is, however, well adapted to a hot dry climate, where there are winter rains, and does fairly well on very indifferent soil. The grain is attractive looking. If sown early it may be sown thinly, but if sown late,—and it is a variety that may be sown somewhat late,—it should be sown thickly, at least a bushel to the acre if broadcast, as although its grains are small, and therefore many to the bushel, the plants are not inclined to tiller much.

Although, therefore, a considerable quantity of Velvet Pearl was, perforce, grown this last season, I *would not advise a wide adoption of the variety.* The Allora Spring is much better as an early variety, and is little if any inferior in its milling qualities, and it is a variety whose popularity is growing, especially for late sowing, the demand for seed being recently very active.

2. Chili or Oregon Club.

Another variety recently inported from California for milling purposes, and sold also as seed wheat, is Chili, or Oregon Big White Club.

There are several varieties agreeing essentially one with another grown under these names in the United States. Although they have been introduced into European countries they have not there come into favour, one reason being the poor yield of straw, which in Europe is a valuable product. This factor would not be so important in this country; therefore these sorts may yet find a place among our cereals. At present they are not much in

use. The specimens from which the present description is drawn are tall and have heads of medium length. The straw is yellow, dull in lustre, coarsely furrowed, very hollow, of medium thickness, stiff, and rather brittle. The smooth, yellow, straight, erect heads are bald, of medium length or rather short, very regular, compact or even crowded at the tip, clubbed, flat, blunt at both ends, and present four or five sterile spikelets at the base. The spreading fertile spikelets contain three grains each. The chaff is of medium length, acute, with bent mucrons, short-awned towards the tip of the ear, rather stiff, dull in lustre and uniform in colour, deep, almost angular-backed, firmly attached, and lies close enough to the grain to prevent much shelling. The grain is of medium size and length, straight, almost hump-backed, plump, opaque, yellowish, plump-bosomed, blunt at the tip, rather blunt at the base, and has an abundant brush, a rather deep crease, and a floury cross-section. A back-crease is rarely visible. The germ-sculpture is one-third as long as the grain.

Fig. 4.—Ear of Oregon Club or Chili, one-third full size. Grains full size.

This is a prolific mid-season variety, subject to rust, and one that must be sown early. There are short-eared and long-eared strains of this variety.

3. Rattling Jack.

A third variety, concerning which there has been considerable inquiry, is Rattling Jack, otherwise known as Grosse's Prolific. (See plate at end of this pamphlet.) This variety is a first-rate sort for the stripper, its even growth making it possible to take off all the heads without choking the machine with straw. It has most of the qualities, good as well as bad, of the Purple Straw wheats, but is more inclined than they to shell. This is an old and well-known sort, which, however, has of late years gone somewhat out of favour. It is quite short and stiff, and grows a dense stool.* The straw is stiff and strong, of medium and rather uniform thickness, very hollow, only fairly tough, distinctly furrowed, and purplish in colour. The sheath of the upper leaf reaches considerably more than half-way from the last joint of the ear. The foliage is abundant, light-coloured, and drooping. The bald, smooth, straight, erect, regular, short, rosy ears are clubbed, quite crowded, flattened, blunt at the tip, tapering at the base, where there are three or four sterile spikelets. The three-grained spreading spikelets are supplied with chaff of medium length. In the lower part of the ear the chaff is bluntly mucronate, but at the tip of the ear there are several rather long awns. The crowding together of the spikelets tends to prevent shelling, though some shelling does occur. The grains are very large, of medium length, straight, of medium plumpness, opaque, yellowish, rather flat-bosomed, blunt at both ends, especially the tip, with a very abundant brush, a rather deep crease, and a germ-sculpture

Fig. 5.—Ear of Rattling Jack, one-third size. Grains full size.

* See the four centre rows in Fig. 19, p. 18.

occupying not more than one-third their length. A back-crease is rarely visible. The interior of the grain is rather floury.

Fig. 6.—Grain of Rattling Jack, average form and size.

Rattling Jack may be called an abbreviated purple-straw wheat. Except in form it completely resembles the purple straws, being delicate, and very liable to rust, but a great yielder in a good season, and on good, well-cultivated land. Though the ears are short, they contain a surprising amount of grain. This wheat will stand gales without breaking down. The grain is of good milling quality, from the Australian point of view.

Prominent characteristics.—Rather short, strong stiff purple straw, short bald club-shaped ears, large yellow grain of good quality, rather early, productive, rust-liable, somewhat liable to shell.

4. Fife Wheats.

The only other wheat that requires particular mention is that sent under various names, such as Duluth and Manitoba. These samples, of which only the grain is sent, belong to the group of wheats very generally known under the name of Fifes. The samples sent have invariably been small-grained and red, and as the above names indicate, came from Canada or the north-western part of the United States. The Sydney millers have found that these wheats produce excellent flour when ground in their mills, and now express themselves as ready to pay the full market price for such wheats if grown locally. This result is precisely in accordance with the results of Mr. Guthrie's analyses, made from Australian samples grown by Mr. Wm. Farrer at Queanbeyan, in this colony. From what I have seen during five years of experiment on these varieties at Wagga, I would not advise their trial in the Riverina. In only one season out of four have they done well at Wagga. In all the other years these varieties have presented a poor appearance. On the other hand, in the colder parts of the Colony, they may do well. Mr. Farrer has for many years grown good samples at Queanbeyan. They should do well in New England and about Orange, and in similar places having a cold winter and late spring.

These wheats are commonly called hard, but this is a mistake, at least in so far as calling them hard implies that they are either harder to mill, or harder in the proper sense of that word, than the average run of Australian varieties. The trial of these varieties should be widely encouraged in our colder districts, for the reason that they are prolific, hardy, and, above all, because they produce a flour of superior value as food. Rightly speaking, therefore, the millers should hold them at a premium. It should not be forgotten that these Fife wheats are late wheats; they should, therefore, be sown early. The following is a description of a typical American wheat of the Fife family:—

Fultz.—A rather tall free-stooling wheat, not far removed from the Fife type, not yet grown to any extent in this country. The foliage is rather abundant and somewhat glaucous. The straw is whitish-yellow in colour, stiff, strong, above medium height and thickness, rather tough, hollow, furrowed, and lustrous. The stalk when ripening is usually green, rarely almost imperceptibly purple. The sheath of the upper leaf is long, reaching more than half-way to the ear. The heads are bald, yellow, smooth—that is, not velvety,—rather long, regular, open, tapering, straight, erect, and have from two to three sterile spikelets at base. The fertile spikelets are three-

grained and spreading. The chaff is uniform in colour, not too firmly attached, and holds the grain only fairly well, deep, close-lying, long, acutish, short-awned towards tip of the ear, stiff, and has a dull appearance. The grain is amber-coloured or reddish, quite small, straight, opaque, rather flat-bosomed, and blunt at both ends; it has an abundant brush. A back-crease is barely visible; when cut across with a knife the section usually appears horny.

Fultz is a well-known latish variety, somewhat above medium height. The best strains of it are prolific, and yield a grain considered in America to be of very good milling quality. It is highly resistant to rust. Manitoba and Russian resemble this variety in type.

Prominent characteristics.—Rather tall, strong, whitish-yellow straw, bald yellow heads, grain of medium size, considered in America to be of very good milling quality, somewhat late, prolific, not liable to shell, highly resistant to rust.

Fig. 7.—Ear of Fultz, one-third full size. Grains full size.

While on this subject it may not be amiss to extract from my letters a few notes on the experiment wheat plots at the Wagga Experiment Farm and the Bathurst Experiment Farm. As explained in a recent number of this journal* these experiments are carried out partly on the row system, and the nature of the system is shown admirably in some recently taken photographs which are here inserted. (Figs. 11, 12, and 19 on the following pages.)

GRAINS OF THREE SORTS OF WHEAT FOR COMPARISON OF FORM, SIZE, AND COLOUR.

Fig. 8.—Grain of Fultz, average form and size.

Fig. 9.—Grain of Rattling Jack, average form and size.

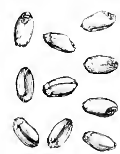


Fig. 10.—Grain of Velvet Pearl, average form and size.

Fig. 11 is of a typical plot, designed to show the difference in yield from seeds of various sizes. The left-hand stooks are from large seed, the next from medium sized seed, the next from small seed. These are from a series of several hundred experiments extending over three years. The results will be published in a few months, and will be far more interesting and useful than those of any other experiments hitherto conducted at Wagga with wheat. Fig. 12 shows some of the manure experiments. Various manures are used in the double rank-growing drills. The intervening three are without manure. These are from a series of over 200 experiments. This is the third year. The results will be ready for publication next year.

There are so many inquiries for a rust-proof wheat and for a "pickle" that will cure rust that I take this occasion to repeat that there is no such thing known as a wheat that is proof against rust. Some varieties resist rust to a considerable degree, and a few in a marked degree, but none of them are proof against the disease.

* Article on Agricultural Experiment Work.

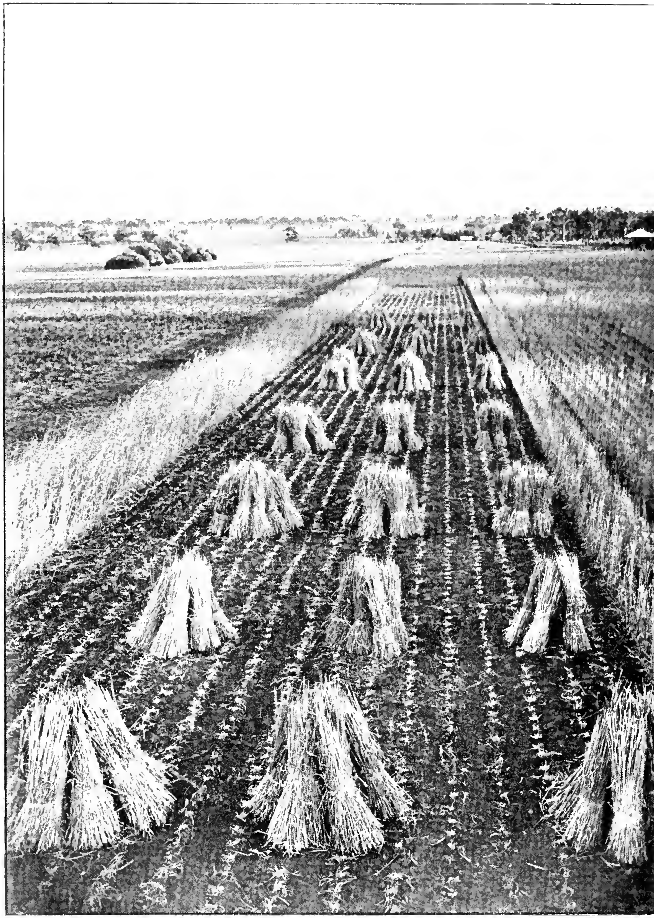


Fig. 11.—Photograph designed to show the method of conducting experiments at the Wagga Experiment Farm. In this portion of the experiment area each row represents a "plot," and is compared only with the row which stands next to it. These particular rows are principal varieties of wheat, such as Talavera, Purple Straw, Allora Spring, &c., being compared with each other over a series of years as to relative yield of straw and grain. The stacks in the distance to the left are various sorts of seed-wheat, each of which of course has to be stacked by itself. The house on the right is a Government farm-employee's cottage. The plots conducted on the row system extend as far as the other house in the distance, and again about half as far in the other direction, *i.e.*, behind the spectator. For the convenience of the visitors the plots are arranged alongside a road, which leads by both the houses shown in the photograph. Nearly all the landscape in the far distance is composed of wheat paddocks.

Fig. 12.—Photograph of part of the manure experiment plots, Wagga Experiment Farm, conducted on the row system. Each long row is compared only with that which stands next to it. This is the third year of the experiments. The average results should be ready for publication in about a year. The results are tabulated most carefully each year, and are open to inspection, but it is the desire to avoid any premature publication. A variety of seasons must be tried first. This part of the manure experiments is directed towards the solution of the questions relating to the application of artificial manure to late-sown wheat, and to the hastening of the maturity of wheat in general—questions which have arisen out of my investigations into the best methods of combatting the disease of wheat known as rust. The road alongside the manure plot leads to Wagga. The buildings, about a dozen in all, are the students' quarters and farm buildings. The trees in the far distance are in one corner of the Wagga Common.

As for curing rust by treating the seed, the idea is ridiculous. It would be just as reasonable to expect to prevent measles among mankind by soaking babies in some sort of pickle. Rust is a disease that attacks wheat after it is above ground. So far as is known the seed is almost never attacked. In this respect rust differs radically from bunt. Bunt does attack the seed—the seed particularly. This is the reason that various solutions applied to the seed will prevent bunt.

Fig. 13.—Spray of flax attacked by rust, natural size. The rust pustules are shown on the leaves and branches. The rust, here provisionally named *Melampsora lini*, Pers., may be described as follows:—

Uredo Stage.—The nearly spherical orange-coloured uredospores form on the stem, leaves, sepals, and capsules of the host plant golden yellow round to oblong, or (on the stem) even linear pulverulent sori, which vary from one to five millimetres in length, the larger sori being undoubtedly due to the confluence of several smaller ones. While yet young the sori have the appearance of small blisters. When the uredosori are mature, the leaves of the host plant are sometimes completely obscured by the powdery mass of uredospores present on its surface. A leaf but little more than an inch in length may bear as many as 200 sori, and even the average number of sori on a leaf often exceeds 100. The uredospores are borne on stalks among numerous capitate paraphyses (see Fig. 14.) These paraphyses occur throughout the sorus, but are less numerous near the centre. Their nearly transparent, smooth, spherical to clavate heads are somewhat larger than the spores, and are borne on stalks longer than those of the spores. The marginal portion of the sorus is composed completely of paraphyses, a fact easily demonstrated by means of sections through the sorus, or by examination from above with a medium power. Each sorus is enclosed in a pseudoperidium composed of a single layer of spherical, or, rather, polygonal cells, whose diameter is about one-third as great as the transverse diameter of one of the epidermal cells of the leaf of the host-plant. This pseudoperidium is often visible to the unaided eye as a somewhat lacerated membrane bordering the sorus. It has been mistaken for the ruptured epidermis of the host-plant. It is easily removed for examination, or its existence and structure may be demonstrated by cross-sections of the sorus. A similar pseudoperidium is known to exist in *Melampsora populina*, and in a few other cases. The origin and development of these pseudoperidia of the uredospore sori have not yet been sufficiently investigated. Such well developed and persistent enveloping membranes are well-known characteristics of the *Æcidium* stage of numerous rusts, and the appearance in the uredo stage is another morphological evidence of the genetic connection between the old form-genera *Æcidium* and *Uredo*. The finely echinulose uredospores germinate readily, and when doing so give evidence of the presence of at least three or four germ spores. They throw out about two hyphæ, only one of which is likely to grow vigorously. This one is of irregular diameter, and often, though not always, gives rise to numerous finger-shaped branches; the total length of the system thus produced often exceeding ten times the length of the diameter of the spore. The germinating spores measure 23 to 29 μ in diameter, being nearly spherical.

Puccinia Stage.—The sessile, one-celled, cylindroid, or perhaps it would be better to say prismoidal, brownish teleutospores are closely packed in dark brown sori, principally on the stem of the host-plant, and for some time remain covered by its epidermis. They are from four to five times as long as broad ($11-15 \times 57-73\ \mu$), being straight near the centre of the sorus, and slightly curved near the margin. At the free extremity of the teleutospore, where the wall is thicker and darker brown, is found a single germ-pore.

The above-described rust may not be *M. lini*, Pers. It is common in New South Wales on *Linum marginale*, a native flax, and has been found on experimental crops of linseed—that is, *Linum usitatissimum*. The linseed is much injured by the rust. According to Barclay, this fungus is apparently extremely common over large areas of the plains in India. The specimen forwarded by Mr. Clout, of Rosemount, Brungle, is a plant grown from Indian seed. Mr. Clout said New Zealand seed gave sound plants.

Various inquiries about the rust on flax lead me to point out that this rust differs materially from that attacking wheat, however much alike the two may appear to the unaided eye, and that it never attacks wheat. Nor does the wheat-rust ever attack flax.

On the other hand the wheat-rust does sometimes attack various grasses, but unfortunately I have been obliged to answer inquiries on this subject for the most part somewhat as follows:—"It is difficult to recommend any

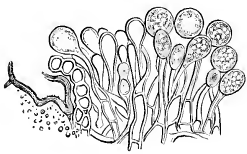


Fig. 14.—Section through part of a flax-rust pustule, showing on the left the marginal peridium of the pustule. x 175.

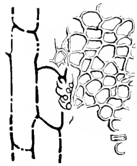


Fig. 15.—Face view of the peridium shown in Fig. 14. The wider black lines are to show the epidermal cells of the flax.

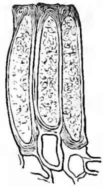


Fig. 16.—Teleutospores of the flax-rust. x 325.

measures against rust on pasture grass. I do not remember to have seen any recommendations on the subject that appeared to be of much value, and my own investigations have led (so far as pastures are concerned) to no practical remedies. Remedies there are, such as spraying with copperas, &c., but the necessary machines are not to be procured in the Colony, and the process is too expensive in any case. No doubt burning off the grass would do something towards lessening the loss, but to be effective the burning would have

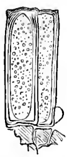


Fig. 17.—Teleutospores of the flax-rust, differing somewhat in form from those shown in Fig. 16. x 325.

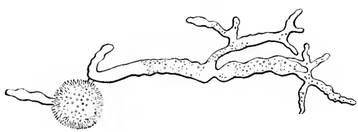


Fig. 18.—Uredospore of the flax-rust, germinating.

to be simultaneous by owners over a large area. Some grasses are much less liable to rust than others, but unfortunately the best grasses for the South Coast districts are the very ones that are most liable to rust. I refer to rye-grass and the various species of Poa."

5. Smuts and Bunt.

Probably no diseases bring me more inquiries from growers of wheat and maize than do smuts. In spite of the fact that the subject of smuts is easy of mastery there is a great deal of ignorance and misapprehension concerning it. I wish the whole community could adopt more precise language in speaking and writing on this question. To this end I wish to explain that our wheats are subject to three diseases of this kind—

1. *Loose smut*, which turns the whole ear to a black mass.
2. *Bunt*, which does not much disturb the form of the ear, but converts each grain into a small ball filled with a stinking black powder.
3. *Flag-smut*, which breaks out on the flags principally.

This latter is disregarded in these pages, because it is uncommon in this Colony.

Loose smut first appears at the time the wheat comes into flower, and this fact is in itself almost a guarantee that this is the period at which it infects the next crop.

Bunt, on the other hand, does not break loose from its ball-like enclosures until harvested and threshed. That is the period at which it infects the next crop, either through immediate contact with healthy seed or by becoming disseminated on the land so as to infect the seed when sown.

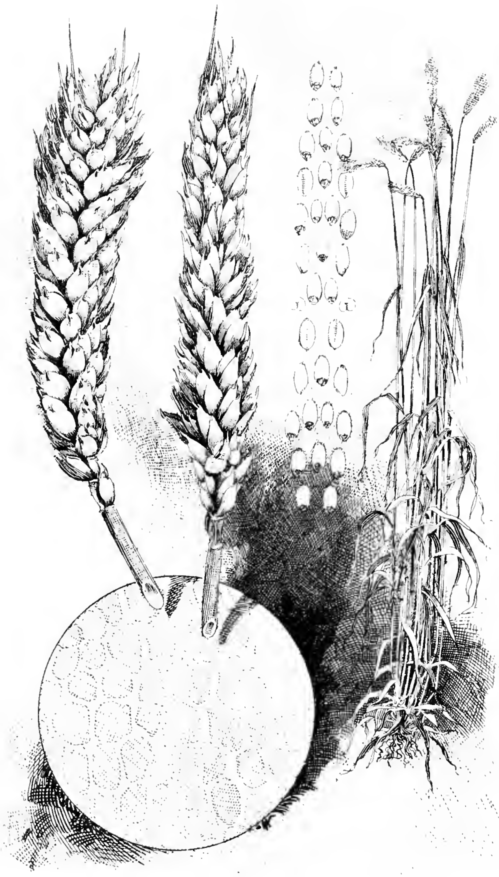
Treatment either with hot water for fifteen minutes at 130°–135° Fahrenheit, or soaking in a weak solution of bluestone or sulphide of potash will prevent the appearance of bunt.

In case of loose smut of wheat, however, I still doubt if any of these treatments can be guaranteed to do very much good. I have treated thousands of samples of wheat with hot water for instance, and while I observe that I am thus able to largely control the disease called bunt, the results as regards loose smut are very uncertain—so uncertain that any success I may attain I am inclined to put down to some unknown factor. For one thing it seems very reasonable to suppose that the state of the weather at the time of blossoming (*i.e.* time of appearance of the loose smut) must have a great influence on the prevalence of the disease the next season, although it is difficult to advance the precise reasons beyond what has been already said.

It is not uncommon for me to receive letters stating that seed wheat treated with solution of bluestone has produced a smutty crop. In most such cases I find the disease to be loose smut, which is again confirmatory of the comparative inefficiency of the above treatments so far as this disease is concerned.

I have found the most certain preventive measure to be the plucking and destroying of all loose-smutted heads. I fancy the owner of a thousand acres of wheat will smile at the idea of going through it and weeding out and burning the smutted heads. That, however, will be because he does not understand my meaning. To make it clear I will describe the method adopted and successfully carried out for four years at Wagga.

To begin with, the seed for the Wagga Experiment Farm was collected during the years 1890 and 1891 from all parts of the world, and it is quite safe to say that I received along with it quite a fair share of every important wheat disease. Stud plots were started, and were located as they should be, namely, on the side of the farm or paddock towards the prevailing wind, or, if not, then at a distance from all other wheat. Unfortunately this rule has sometimes had to be abandoned, but always, I am now convinced, with disadvantage. Each stud plot, one for each principal variety, was grown from selected seed. When ripe, and during growth, the plants were inspected, and all the diseased ones removed and destroyed. This gave a crop of healthy seed. The reason the windward side of the field was preferred as a location for the stud plots was the fact that in that position fewer spores, either of smut or other diseases, would be blown on to the plants it was desired to improve by selection. They would thus be kept all the more free from disease. A few of the very best plants from each stud plot were reserved so as to secure seed for a similar stud plot next year. The remainder (after all undesirable plants had been culled out, see Fig. 19) was used as seed wheat next year, and produced a few acres of as healthy wheat as could be obtained. The seed, being derived from healthy plants, did not need to be treated with hot water or anything else, so this expense was saved. These few acres were subjected to a less rigid



RATTLING JACK.

THREE-FOURTHS FULL SIZE.

The circle illustrates the microscopic appearance of the so-called gluten layer.

inspection and again used for seed, this time producing (say) 50 acres of wheat. Meanwhile the second stud plot had furnished another half bushel or more of healthy seed, and a few extra good plants with which to start a third stud plot.

The continuance of this system (see Fig. 19), when once inaugurated, insures a constant supply of healthy seed wheat of superior quality; and of the good results of the method, I wish to give farmers the most positive assurance.

Though the carrying out of this system with such a large number of wheats as are handled at the Wagga and Bathurst Experiment Farms is somewhat expensive, the extra cost is due solely to the strict and skilled supervision that has to be exercised in order to insure accuracy in the work. With only one or two varieties on an ordinary farm the method is a very simple one, and one that should be very widely adopted.

About three years are required to get this system of producing seed wheat into good running order, after which it will give very little trouble, and pay its way ten times over every year in the superiority of the resulting crops, not only through their freedom from smut and other diseases, but in extra yield and quality of the grain.

There is, however, one factor in this method of wheat-growing that must be watched, and that is the land on which the bulk of the wheat grows. If this land is contaminated with bunt to begin with, bunt will continue to appear in succeeding crops. This can be largely prevented by introducing a change of crop, or by fallowing the land.

For the full particulars of the method of treating the seed with hot water and with bluestone I must refer the reader to Vol. II, p. 672, of this *Gazette*.

6. Maize Smut.

Formerly, when writing on maize smut, while suggesting treatment of the seed with bluestone or hot water, I threw doubt on the efficacy of these treatments, and strongly advised that, where small areas of maize were grown, all smutted parts of the plants should be collected and burned, especially if maize was to be sown again immediately on the same land. I did this from life-long familiarity with this disease, and the failure, in my own case, of any method of combating this disease, other than that of destroying the smut as fast as it appeared. As, however, owing to the great similarity of the maize smut-fungus to others which were known to enter the crop by way of the seed, it seemed probable that maize-smut also attacked the seed, more especially as this was already widely assumed to be the fact, I thought best to give countenance in this journal to the treatment of the seed, as was the custom in other pathological publications. Now, however, Dr. Brefeld, who for many years has made a speciality of the smut-fungi, after long and careful study, has come to the conclusion that maize first becomes infected with smut after it is at least a foot high, and principally through the spores of the fungus dropping into the "cone" formed by the latest well-developed and topmost leaf. This important discovery is in full accordance, I believe, with the experience of those who, like myself, have produced no satisfactory results by treatment of the seed of maize that is grown in the ordinary way. The full significance of this matter is not fully grasped until we realise that *henceforth we are relieved, so far as maize smut is concerned, from the expense of treating the seed.* This is no small item when considered in a national light.

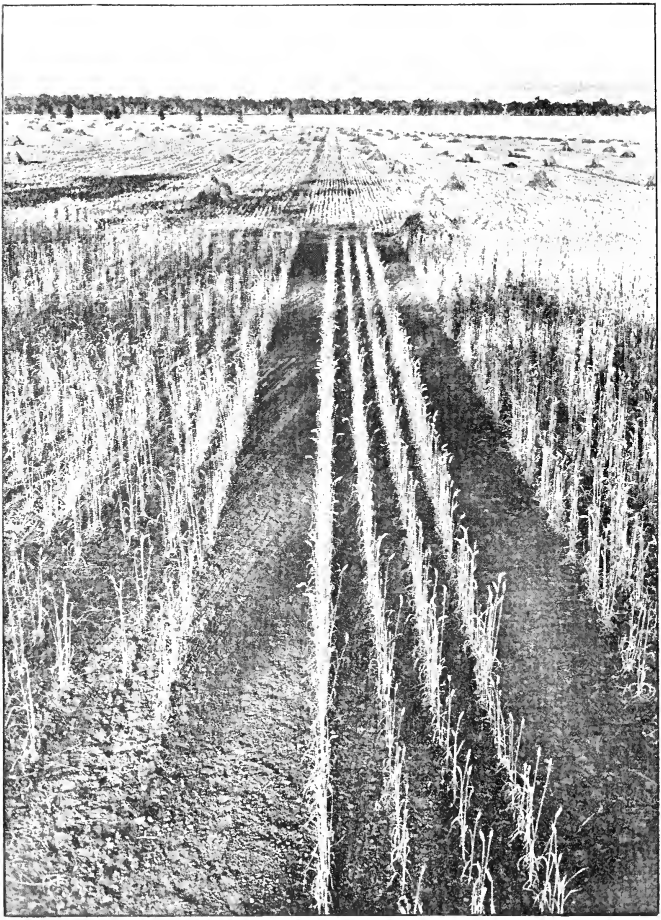


Fig. 19. Partial view of two stud wheat plots at the Wagga Experiment Farm. The plot on the left has been weeded out as described in the text; so has the plot on the right. The four rows in the middle of the picture have not been weeded out. It will be noted that in some parts of the left-hand plot nearly all the plants have been pulled up and removed for one reason or another. The plants left standing, having passed the inspection, are next reaped and threshed. The wheat stooked in the middle distance came from a stud plot of the year 1894 in other words, is the second generation of seed from just such a plot as is shown in the foreground. The distant paddock, just this side of the uncleared land, is unent wheat, also on the Experiment Farm.

7. "White-heads" or White Blight of Wheat.

A disease often spoken of as "white-heads," characterised by the bleached appearance of the full grown wheat plants, and by the absence of grain from the heads, is not infrequently the subject of inquiry by farmers. This disease was treated of in my article on Take-all,* under the special name of "White Blight." Observations and experiments since made confirm the opinion that this disease is one connected more particularly with the soil, though probably some organism is the primary cause. The treatment formerly recommended is still more fully endorsed.

Remedy.

Apply lime to the diseased patches as a manure, at the rate of about 1 ton per acre. In the absence of lime, the ashes obtained in burning off may be utilized with almost equally good effect.

II. Diseases of the Plum.

Disease of the Japanese Plum.

Numerous varieties of plums, especially Japanese varieties, have been sent to me this season, attacked by a disease about which I have as yet discovered little except that it was undoubtedly serious. The fruit is misshapen, failing to grow, more particularly on one side. The defective side has an irregular and roughened surface, from cracks in which gum sometimes oozes. With the prevalent notion that the disease is "sun-scald," *i.e.*, is due to the heat of the sun, I cannot agree, because as often as not I find the diseased side turned away from the sun. The disease seems to me to be one connected in some way with the wood, and to be perhaps related to the disease known as gumming. I suspect it to be transmitted through grafts.

Remedies.

1. If a tree shows the disease very badly for three years in succession either remove it or graft on another variety known to be not subject to the disease.
2. Do not buy trees except under a guarantee that they are grafted from healthy trees.
3. Do all you can to spread the information that cuttings taken from diseased trees are likely to produce diseased trees even if grafted on to healthy stocks.
4. I can hold out little hope that any sort of spraying will be beneficial, but if other trees are being sprayed there would be no harm in trying the effect of Bordeaux mixture on this disease.
5. According to my observations plums grow to the greatest perfection on limestone soils. This seems to point to the use of manures rich in lime. Potash is also desirable.

The letters accompanying these specimens of diseased plums have sometimes inquired whether the disease is not "Plum Pockets." So far as I know, the disease known by the name of Plum Pockets does not occur in this country. As the name of this latter disease implies, the plums are converted by it into "pockets," that is they become hollow and have *no stone.* I have never seen such objects in Australia, and therefore conclude that they are at least uncommon.

* *Agricultural Gazette of N.S.W.*, Vol. III, p. 991.

III. Diseases of the Apple.

1. Bitter Pit of the Apple.

I mention this disease only to state that Mr. Robinson, of Ashfield, at my suggestion, has undertaken some experiments in order to find out if possible whether this disease is transmitted by grafting, as I strongly suspect it is. The results will be made known in due time. I think it will be no breach of confidence to mention that experiments conducted by officers of the Victorian Department of Agriculture are believed to show that this disease cannot be alleviated by any kind of manure.

2. Canker.

The common and wide-spread diseases of the bark of trees known under the general name of *canker* continue to trouble our orchardists as of old. A few words suggested by the nature of the specimens and inquiries I have received during the last few months may therefore be of service.

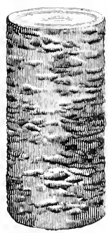


Fig. 20.—Canker on a limb of apple. The disease appears in this case as small elongated brownish "blisters," arranged transversely on the limb.

The cause of most canker spots is external. Frost, sun, hail, insects, or violent winds first of all injure the bark, and then some parasitic or semi-parasitic fungus attacks the wound thus made and increases the "sore" faster than the bark can produce "healing" tissue. The process goes on from bad to worse until, in some cases, it seems as if there were no limit to the consequent "sore" or excrescence. I have seen such deformities a yard or more in diameter. The disease is generally long drawn out, and in the case of fruit-trees is particularly disheartening when severe. Among fruit-trees, apple-trees are probably more subject to canker than any others, though even they are less subject to it than some timber trees. As a matter of fact, nearly all the specimens of canker recently sent to this Department from the orchardists of the Colony are from apple-trees. Those who are curious concerning the nature of the fungi causing canker may find some satisfaction in studying the adjacent illustration, which was prepared from some diseased material sent me recently, and when they have done so will readily understand why the following recommendations were made.

Remedies.

1. Prune off or cut out the worst cases, and then apply grafting wax to the freshly-made cut. Use sharp tools and do not cut sparingly. If you do not remove all the diseased bark, the disease will remain and continue to spread. Cut away all the bark that appears in the least swollen, discoloured, or in any way unhealthy. Burn the cuttings.

2. As soon as you can find out the original cause of the wounds remove it. If it is the sun scalding the bark, prune the trees so as to cause the foliage to shade the limbs and trunks more completely; protect the trunks of young trees from the sun by some artificial means if necessary. Provide wind-breaks. Remove any superfluous old bark, the scales of which may harbor insects.

3. Whitewash is a good substance to apply as a destroyer of the spores or other propagating agents of the fungus. Bear in mind that a thin whitewash can be very economically applied with a spray-pump and a coarse Nixon

Fig. 21.—Showing young fruit-tree whose trunk is protected from the full force of the sun's rays by means of a cylinder of very thin veneer sawn from bark or other material.

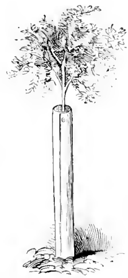
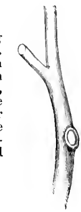


Fig. 22.—Limb of a tree showing proper and improper pruning. The upper branch has been sawn off too far from the main limb. The lower branch, having been sawn off close to the main limb, will heal over more successfully, and give canker fungi much less opportunity to gain entrance and do damage.



nozzle. One advantage of this method of applying the wash is that the smallest twigs can be whitewashed, a thing not feasible with a brush.

4. A winter spraying with the strongest Bordeaux mixture will do good. The great advantage of a winter spraying is that the solutions may be used much stronger than when the tree is in leaf. Solutions that would injure the foliage may be applied in winter to the bark and buds with impunity.

How simple and reasonable all these remedies seem when once the nature of the disease is understood!

IV. Diseases of the Potato.

1. Wet Rot.

While the name *wet rot* is very descriptive of this disease, the name *stinking rot* would be still more appropriate. The disease attacks potatoes in the ground as well as in store, and reduces the tubers to disgustingly stinking, almost liquid masses of mattery-looking rot. Often the whole potato is found so rotton that the slightest attempt to move it causes it to collapse into a semi-liquid mass. Again, only part of the potato will show the liquid rot, the remainder having not yet succumbed. In the earliest stages, while the potato is still hard, the rot may be detected by a dark band which can be seen somewhat below the skin when the potato is cut in two.

Though it seems fairly certain that the disease is caused by a microbe, it is as yet uncertain what is the exact relation of the microbe to the potato plant. The disease never occurs without the presence of the microbe, and the disease may be transferred from one potato to another with great ease, merely by inoculation with some of the putrescent rot. The microbe has been isolated and cultivated and described. The difficulty arises when we come to consider the relations of the microbe to the stalk of the potato. A disease-producing microbe occurs in the stalk, more particularly in connection with the fibrovascular bundles, it is said, and the question that naturally presents itself is this, "Are these microbes in the stalks identical with, or in any way related to, those in the tubers?" and this question has yet to be definitely settled. Fortunately for growers these questions do not stand in the way of suggesting very definite and effective remedies.

Remedies.

1. Avoid seed from a crop that has shown wet rot.
2. Buy seed only on a guarantee that it comes from a perfectly sound crop.
3. Where land has borne a diseased crop of potatoes, do not again immediately use it for potatoes. Give it a rest, or put in some other crop.
4. Land lower down than that suffering from wet rot and receiving drainage from the contaminated land will also sometimes develop the disease. Avoid such land for potatoes.
5. Destroy the worst affected potatoes by fire. Boil the remainder of the diseased tubers for the pigs, poultry, or other stock. The apparently sound portion may be used for the table. In fairness to other people such potatoes should not be sold, except with a full statement as to the facts of the case.
6. Disinfect all bags, bins, and other receptacles that have held wet-rotted potatoes. Boil the bags and whitewash the bins. I believe the steamboats plying along the coast and to Tasmania and New Zealand are responsible to a considerable degree for the spread of this disease. The precautions just mentioned are inexpensive, and might with advantage be more often adopted by the steamship companies.
7. Do not store diseased potatoes along with healthy ones.
8. Pick over the stored potatoes from time to time. Throw out and destroy the diseased ones.
9. Induce as many of your neighbours as you can to adopt these precautions. Their vigilance will benefit you.

Potato Scab.

This is a well-known disease of the potato, characterised by the scabby appearance of the whole or part of the surface of the tubers. The same

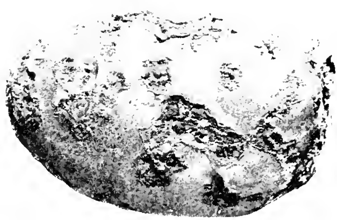


Fig. 23.—Photograph of a scabby potato, natural size. The roundish and irregular-shaped rough and corroded spots are due to the attacks of the scab organism, and it is from these scabs that spores or other agents responsible for spreading the disease are derived. The depth to which some of the scabby spots extend is well shown at the top of the illustration, where a deep cavity is shown in profile. By soaking the potatoes in corrosive sublimate solution these scabs are sufficiently penetrated by the poison to be well disinfected, yet the potato tissues themselves, being comparatively impenetrable, are not injured.

disease is said to occur on beet-roots. It occurs in all sorts of land, but is more prevalent in sandy soils and in soils containing much lime, and is said to be more virulent in crops fertilized with manure containing much common lime, or with wood ashes. The disease is confined largely to the tubers, the appearance of which, when thoroughly diseased, is shown in the above illustration.

The cause of the disease is still in dispute, but there can be little doubt that it is a minute vegetable organism. On the one hand it is claimed by some who have investigated the disease with care—and their view has at present the most supporters—that the cause is a fungns of low degree,* and on the other hand by others who also seem to have been careful, that the cause is a microbe. These latter do not deny the presence of the fungus

* The Oospora scabies of Thaxter.

first mentioned, but suggest that it is a concomitant of the microbe which really causes the disease. Here again, however, the doubt as to the precise course of the disease has not prevented these specialists from deducing from their investigations certain remedies which are, on all sides, admitted to be very effective.

Remedies.

1. Avoid seed from your scabby crops.
2. Buy seed only under guarantee that it comes from a perfectly healthy crop.
3. Where land has borne a scabby crop do not immediately again use it for potatoes, unless the seed be soaked in corrosive sublimate or the land be dosed with sulphur.
4. Land lower down than that suffering from scab, and receiving drainage from the contaminated land, may also develop the disease. If convenient, avoid such land for potatoes.
5. If land that is subject to scab is to be again planted with potatoes, or if scabby potatoes must be used for seed, soak the seed for one and one half hours in a solution of corrosive sublimate, made by dissolving 10 ozs. of corrosive sublimate in 60 gallons of water.

Corrosive sublimate, or as it is otherwise called, bi-chloride of mercury, is a violent poison if taken internally, and should be handled and stored with care. It must not be placed in contact with metals, as it corrodes them rapidly, and at the same time loses its own properties. The solution used for soaking the potatoes must be placed in a wooden vessel having no internal metal parts. There is no danger in putting the hands into the solution, but it would be well to rinse them afterwards in pure water. The solution does not injure cut potatoes, and if the potatoes are to be cut for seed they should be cut before being soaked, as the cutting of the soaked potatoes would be ruinous to knives. Plant the potatoes without rinsing them, but allow them to drain. Corrosive sublimate can be had from any chemist, and costs from sixpence to a shilling an ounce. Several bushels of potatoes may be treated for a few pence, and the treatment is very effective.

Sowing flowers of sulphur at the rate of 1 to 3 cwt. per acre along with the seed potatoes appears to have been attended with a very marked diminution of scab, and the good effects of one such treatment are said to continue more than one season.*

6. Boil up the worst of your scabby potatoes and feed them to stock. Also boil or burn the parings of such scabby potatoes as may have been used for the table. Scab begets scab, and the more of it there is left about, the more will be begotten to attack your future crops of potatoes.
7. Disinfect all bins, bags, and other receptacles that have held scabby potatoes precisely as for wet rot (See p. 22.)
8. Do not store scabby potatoes along with healthy ones, though this recommendation has much less force in connection with scab than in connection with wet rot.
9. In case you are troubled with scab, avoid for potatoes, barnyard manure and such fertilizers as contain much lime. Wood ashes are not desirable where scab is prevalent, and potash should be supplied in some other form. Carbonates should also be avoided. There are plenty of artificial manures so concocted as to avoid the above pitfalls and yet be very suitable for potatoes. Moreover, it appears that such fertilizers are themselves to no inconsiderable extent a remedy for the disease, especially on so-called sour soils deficient in lime.†

* 17th Ann. Report, New Jersey Ag. Exp. Station.
† Wheeler, Tower, and Tucker, R.-I. Exp. Station, Bull. 33, 1895.

10. Induce as many as possible of your potato-growing neighbours to adopt the above precautions. If they adopt them you will also be benefited.

Caution.—There is a moth, *Lita solanella*, whose grub attacks potatoes, and causes appearances which sometimes resemble scab. These deceptive appearances, due to the attacks of the potato moth, have given rise to trouble in the following manner. The grower, mistaking the moths' ravages for scab, treats his seed-potatoes with corrosive sublimate, with no benefit, and thereupon denounces the remedy. This is an unfortunate mistake, because although the corrosive sublimate solution is almost harmless to the potato-moth, it is very effective indeed against potato-scab. The ravages of the moth are easily detected by cutting open a few potatoes. The passages eaten by the grub will be seen under the skin, and even going right through the potato from side to side. The grubs are also easily found. Scab does not *penetrate* the potato as the grubs do.

V. Diseases of the Orange.

The Australian diseases of the Citrus fruits have never yet been properly investigated, and the following notes on this subject are only such as my recent letters contain. They may, however, serve as an introduction to a more complete report which is in preparation.

1. Melanose. (?)

This disease is very well illustrated by the photographs I have taken at various times from specimens sent me or gathered for the purpose during visits to various orchards. (See figs. 28 and 29.) I have little doubt that this disease, as it occurs in Australia, is identical with that described by Messrs. Webber

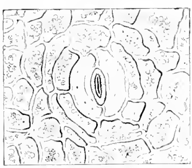


Fig. 24.—Healthy breathing pore in the skin of an orange as seen under the microscope. The cells of the orange-skin are shown containing bodies derived from the chlorophyll bodies, but now coloured with an orange pigment. The two large crescent-shaped "guard-cells" are shown encircling the elongated breathing pore.

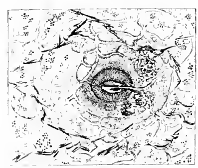


Fig. 25.—The beginning of one of the numerous small spots characteristic of the disease Melanose (?). Each spot begins at a breathing pore. This illustration should be compared with Fig. 24. It will be seen that the interior cells of the skin of the orange have begun to alter in colour. The guard-cells have begun to disappear, and faint traces of mycelium can be seen in the dark colouration near the breathing pore.

and Swingle as occurring in Florida. Still, my observations do not altogether agree with theirs, and the two diseases may be different. Until a definite difference can be pointed out, I prefer to adopt their melodious name.

The differences I note between what I have seen and what the Florida specialists have recorded in the only report of their work that I have seen, are briefly the following. The numerous small madder-brown spots, characteristic of the disease, have a tendency on our varieties of orange to group themselves in curved lines, somewhat like those charted archipelagoes, due to sunken mountain chains, which one may observe at various places on a globe or map of the world. This resemblance is so striking that before I had seen the American report I had begun to call the disease the *archipeligo disease*,

a perpetration which I gladly abandoned in favour of the more euphonious American term. Again, I note that the small diseased spots start at the breathing pores, or stomata, of the orange, as shown in the woodcuts on page 24, which have been very carefully prepared, and give an excellent idea of the appearances, as seen with the microscope. Moreover I find, on examination of the edge of well-developed spots, a well-developed but somewhat peculiar mycelium. This is better pictured in Fig. 26 than in any words of mine. Finally, I note that on the leaves the spots due to this disease are more elevated and blacker than on the fruit.

Fig. 26.—Mycelium and conidia from the edge of one of the small diseased spots shown in Fig. 29, &c. Magnified about 350 times. *a*, *b*, mycelium; *c*, *c*, hyphae bearing sporidia.

I can have no doubt, and I think the scientific reader who trusts to my accuracy of observation will agree with me, that the fungus mentioned and pictured above is the cause of this disease. Experiments have shown me that the mycelium of this fungus ceases to grow after the application of even weak Bordeaux mixture, and experiments in the orchard, so far as they have proceeded, confirm those made in the laboratory. Moreover, both these results are in accord with those achieved in the orchards of Florida.

This disease is known to our orchardists, in the county of Cumberland at least, as Orange Rust, and occasionally as Maori. I think both these names should be abandoned in favour of Melanose. The disease is in no sense a "rust," the name of "rust" being one that should be reserved for those diseases caused by fungi related to the well-known wheat-rust. Maori is a name already in use for a distinct disease of the orange, concerning which I will here only remark, that it sometimes resembles Melanose in a very marked degree, a fact that is sometimes very puzzling to orchardists, especially as the two diseases often occur on the same orange, as shown in one of my photographs on page 26.

Fig. 27.—An orange affected with the disease known as Maori, showing the *continuous* nature of the brown colouration characteristic of this disease. The colouration does not in this case extend over the whole orange, though such is frequently the case.

There is no doubt that Melanose is doing much damage among the orchards around Thornleigh and Parramatta. Last season oranges spotted over with the disease were to be found in the Sydney market literally by the ton. Even where the tree is not prevented by the disease from bearing a crop of fruit, the surface of the fruit is so disfigured by the multitude of small dark spots as to have its market value seriously diminished. In

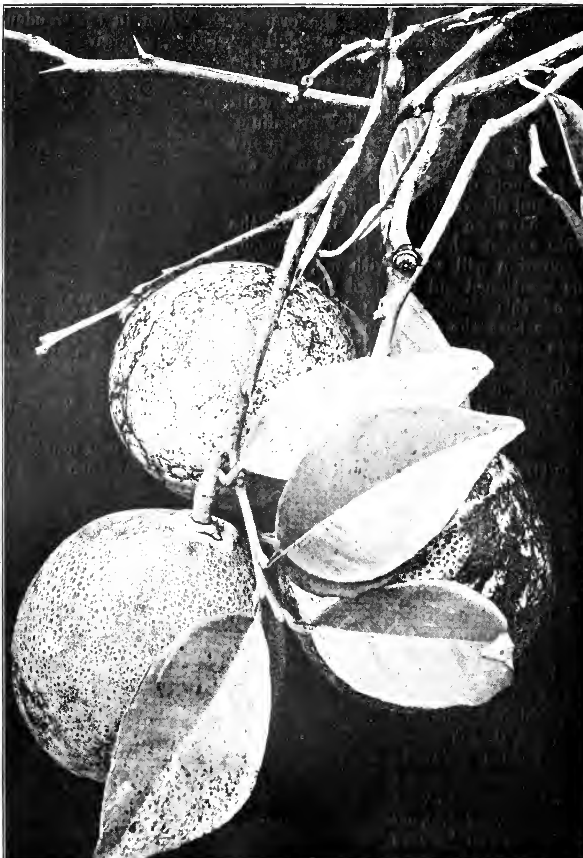


Fig. 28.—The disease Melanose (?), as it appears on the fruit and leaves of orange-trees at Pennant Hills, about 10 miles from Sydney, N.S.W. The two left-hand oranges show the disease without any complications, the upper one more especially showing the arrangement of the small diseased spots in archipelago-like groups, while the lower shows a more advanced stage of the disease in which the spots have run together (lower left-hand part), or have developed a distinct mycelium at the edges (upper right-hand part). The right-hand orange shows the disease Maori as well as Melanose, this latter disease appearing somewhat in the shadow of the leaves, while the Maori is most conspicuous on the extreme right. All the leaves show Melanose (?), but it is most marked on the lowest leaf. The bark of the young twigs is also slightly attacked. As this photograph was taken in the orchard from perfectly fresh material the effect is very faithful and lifelike.

vain the vendor says, "Oh, that? That's nothing; quite harmless!" The customer shakes his head, and can be tempted only with a low price. Unfortunately this is not the worst feature of the case. Many trees are now suffering so much from Melanose that the crops are diminishing; and I have seen trees in a dying condition, that seemed to be suffering principally from this disease.

Remedies.

1. Prune the trees rather severely, taking the precaution to remove the branches that show the most disease. Prune with an eye to spraying, that is, leave the tree so that every part will be accessible to the spraying machine nozzle. Burn the cuttings.

2. Begin as soon as the fruit has set, and spray with Bordeaux mixture, of one-half the usual strength, once every ten days or two weeks, until about a month before the fruit ripens. The Bordeaux should contain only 3 lb. of copper sulphate to 40 gallons of water, or it may even be more diluted than this. Bordeaux mixture of the usual strength sometimes injures orange trees.

Fig. 29.—Four oranges attacked by Melanose (?), showing the curved markings caused by the peculiar arrangement of the small diseased spots. Though these small spots may run together, more or less, so as to cause brownish patches somewhat resembling Maori, they never become amalgamated into the uniform continuous colouration characteristic of the latter disease. However much they may run together they never cease to be spots; so that any patches of colouration they may cause are discontinuous—palpably made up of spots.

3. Spray the trunk and larger branches with thin whitewash or full strength Bordeaux mixture.

4. Apply to the ground under each tree half a pound or more of sulphate of iron in 25 gallons of water; all the better if applied during a dry spell.

5. Give the trees phosphate and potash manures, but avoid organic nitrogenous manures, such as dried blood and rich stable manure. The use of somewhat bleached stable manure that will act also as a mulch is not hereby deprecated.

6. See to it that the drainage is good. Bad drainage is a prolific source of disease among orange trees.

7. Where the use of too much organic nitrogenous manure has already caused a rank soft growth of foliage particularly subject to disease, this objectionable material may be absorbed from the soil, according to Webber and Swingle, by allowing the weeds to grow.

8. If possible, induce your neighbours to adopt these precautions. Your fortune is more or less bound up in theirs, so far as contagious diseases are concerned.

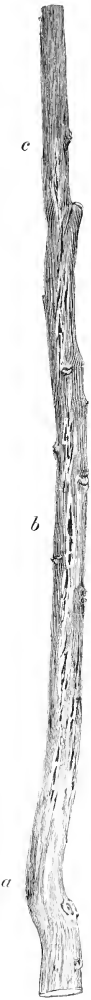


Fig. 30.—Young orange stock, one-half natural size, the bark of which has been attacked by a fungus. The diseased bark is shown in the lower part, where it is more or less yellowish, being very much lighter coloured than in the upper part *c*. From *a* to *b* the bark is cracked. The fungus whose spores are shown in Fig. 31 occurs more particularly in the neighbourhood of these cracks.

2. Mal di Goma.

This is a disease of the bark of citrus-trees which rarely extends more than 18 inches above the ground, and hence is sometimes also called collar rot. It attacks trees of all ages, and is more particularly found where the drainage is bad. The bark first of all turns yellowish, and has a gummy consistency and a sour or fermenting odour. The disease continues to spread until, in some cases, the tree is girdled and dies.

Fig. 31.—Spores of the fungus found attacking the bark of young orange-trees, and causing the appearance shown in Fig. 30. These ellipsoidal, colourless, smooth-walled spores arise from minute dark pustules occurring singly or in groups here and there on the bark. The spores measure $3-3{\cdot}5 \times 3-6\,\mu$.

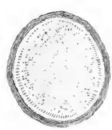


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Fig. 32.—Cross-section, natural size, of the young orange-tree stalk shown in Fig. 30. This section was taken near *c*, and is in a fairly healthy condition. The bark is shown dark, and the wood radiated. Compare with Fig. 33.

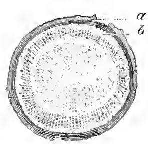

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Fig. 33.—Cross-section, natural size, of the young orange-tree stalk shown in Fig. 30. This section was taken near *b* Fig. 30, and shows the effect of the disease. One of the cracks in the bark is shown at *a*. At *b* the effect of the disease is shown on the newly formed wood, which has become thickened. Compare with Fig. 32.

Occasionally half girdled trees recover themselves, and go on growing and bearing, though the trunk does not heal over.

Observations have been made tending to show that this disease is caused by a fungus, but some doubt seems to exist as to the real cause. The illustrations herewith,

show that in at least one case of apparent *Mal di Goma*, forwarded to me at my special request, a fungus occurred in the diseased bark. The nature of the case is well shown in the engravings and their subjoined explanations.

Remedies.

1. Cut away the diseased bark with sharp tools. Cut well into the wood and remove every particle of diseased-looking bark. It is better to cut away too much than too little. Burn the cuttings, and smear the cut surface over with grafting wax.

2. Remove the earth from near the base of the tree and apply two or three pounds of slaked lime.

3. Secure good drainage.

4. Avoid organic nitrogenous manures, such as dried blood and rich stable manure.

5. Whitewash the trunks with a spraying machine, or with a brush.

3. Verrucosis.

This is a disease that affects lemons particularly, giving rise on the fruit to unsightly warts of a light brown colour which are particularly noticeable on the lemons when they are green. The disease causes many young lemons to drop off, and it so deforms many others as to cause them to be comparatively worthless. The disease is of fungous origin, and is said to yield to systematic treatment with Bordeaux mixture. For specific directions the reader is referred to the remedies given under "Melanose," p. 27.

4. Die-back.

This disease appears to be somewhat uncommon in this country, but cases have been referred to me that appeared to be no other than cases of dieback. There was the same abundance of small foliage of unnatural colour, and so forth, but the matter must remain unreported upon until I obtain further information, to which perhaps some of our orchardists may assist me.

5. Black Spot of the Orange.

This disease is one that is very prevalent in some of the orange orchards near Sydney. Like Melanose it lowers the market value of the fruit. It also makes it impossible to keep the fruit in store, as the spotted oranges soon become rotten. The appearance of Black Spot on oranges is well shown in the illustration on the following page, (Fig. 34.) It will be seen that the round sunken spots are large and conspicuous, and seriously mar the appearance of the fruit. The central part of each spot becomes greyish or whitish when the fungus causing the disease is mature, at which time several minute dark pustules appear in each spot. These pustules give rise to a multitude of spores of the form shown in the wood-cut below. These spores arise after the manner of those of the genus Gloeosporium. It is therefore possible that the Australian form is the *Colletotrichum adustum* of Ellis.

The amount of damage done by this disease is variously estimated, but is on the whole, I think, exaggerated. According to my observation it causes much less loss than Melanose, though in some orchards the Black Spot predominates, and in such cases is responsible for much damage.

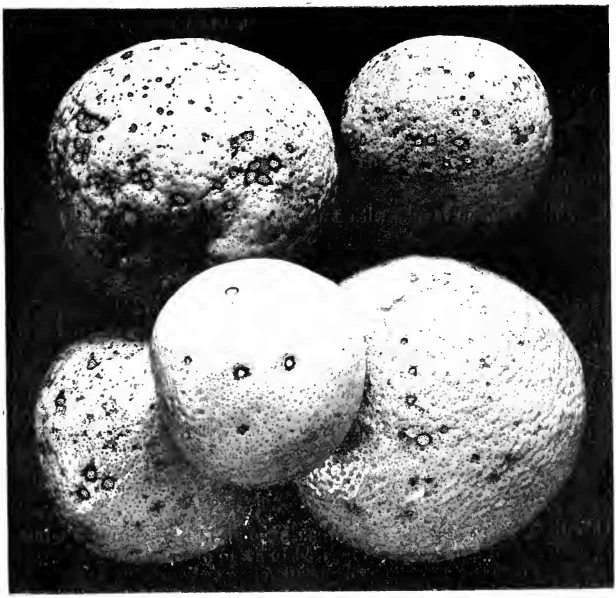


Fig. 34.—Oranges attacked by so-called "Black Spot." The diseased spots occur as more or less isolated roundish sunken, at first dark-coloured spots, the interior portion of which, however, at maturity is lighter coloured, with small dark spots (pustules) at the points where the spores break forth. These five oranges show no other disease all the various defects seen on the skin are due to Black Spot.

Remedies.

1. Laboratory observations show that even dilute Bordeaux mixture poisons the spores of the fungus causing Black Spot. This points once more to the use of this well-known mixture as a preventative. From the nature of the fungus it is plain however that the spray can act only as a preventative, and therefore the treatment should be begun early, and continued right through

the season, and results must not be expected to be completely satisfactory the first season. This is owing to the deep-seatedness of the fungus causing

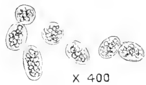


Fig. 35.—Conidia of the fungus causing Black Spot. These ellipsoidal, colourless, one-celled conidia, measuring $7-8 \times 10-15\ \mu$, are enclosed by a smooth and thin cell-wall, and are borne in large numbers in tandem fashion from the mycelium at the base of the interior of the pycnidium in a manner entirely similar to those of the Bitter Rot of apple. Compare with Fig. 36.

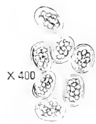


Fig. 36.—Conidia from "Black Spot" as it occurs on the rind of the lemon. Compare with Fig. 35.

Fig. 37.—"Black Spots" on the surface of an orange, natural size. That on the left is from the amalgamation of several simple round spots.

the disease. It will readily be seen that if a disease-producing fungus is growing under the surface of the skin no spray except such as would destroy the skin of the fruit can reach the source of the disease. If, however, a weak Bordeaux mixture be persistently applied, all the spores that arise from the fungus will be killed as fast as they come to the surface, and this must in time stay the spread of the disease. The strength of the mixture should be the same as for Melanose. Begin as soon as the fruit sets, and spray regularly once in about ten days for the entire season. Of course this need not be kept up indefinitely. There is an idea somewhat prevalent that spraying to be effective must be continued indefinitely, and this idea sometimes causes spraying to be looked upon as a losing game, and it is indeed true that in many cases, at present prices, spraying, if it must be kept up indefinitely, would never pay. The fact is, however, that if conscientiously carried out for an entire season, or at the outside two entire seasons, spraying, in the great majority of diseased orchards, would effect such a change for the better that for some time, or even indefinitely, the treatments might be discontinued, or at least made few in number. Those who have looked askance at spraying may, when they consider it in this light, see fit to

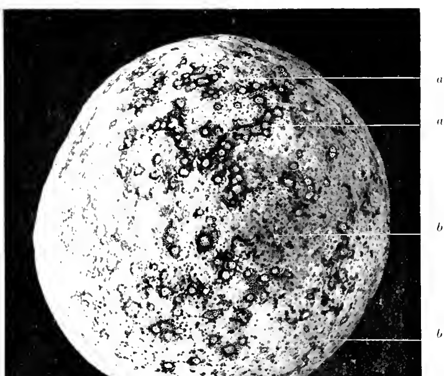


Fig. 38.—Orange attacked by both Black Spot and Melanose (?). *a a*, Black Spot; *b b*, Melanose (?).

change their minds. Granting that it is a losing game for one season, how does it turn out in the long run? Will not a possible loss sustained the first season be more than recouped the next season? These are questions that should not be overlooked. And they are questions very pertinent to the disease now under consideration, and to some others of a similar nature.

As to other measures to be taken in fighting this disease I can only refer the reader to the items on pages 24 to 28, under the head of Melanose, with the caution, however, that the utility of some of them in the present case is somewhat questionable. Whenever you can persuade a neighbouring fruit-grower to adopt any of these measures, count it as money in your own pocket. Winds and flying creatures are constantly transferring the germs of disease from one orchard to another, so that the health of your neighbour's orchard is a matter that concerns you only somewhat less than that of your own.

To the novice in the diseases of oranges the various resemblances among the diseases Melanose, Black-spot, and Maori are a source of confusion. Two or three of these maladies may appear upon the same tree, or upon the same orange. Such cases, and they are very common, are shown in Figs. 26 and 38. This matter would not be a matter worth mention were it not that the treatment varies for each of these diseases. It is much better, therefore, for the orchardist to be able to distinguish one from the other. A careful comparison of the illustrations with which I am able to accompany this article, and a perusal of the explanatory remarks under each illustration, should enable anyone, it seems to me, to readily identify each of these three diseases. I will only add that Maori is a disease commonly supposed to be caused by a small mite, the result of whose attacks is to cause the skin to turn uniformly bright brown in colour, like a Maori's face, and not brown in spots as in the case of Melanose.

VI. Diseases of the Peach and Nectarine.

1. Peach Freckle.

This disease occurs also on nectarines, causing the same freckled appearance on this fruit as that which has caused me to give it its popular name—an appearance that is familiar to most people because of its commonness on late peaches.

2. Peach Curl.

This wretched disease is apparently as common as ever. Where a tree has shown the disease badly for three years in succession and in spite of treatment, I would advise pulling it out and burning it. I am far from satisfied with any remedies I have ever tried, or seen tried, or even heard of. The various things that may be tried are here given but without much hope that they will effect a cure.

1. Collect and burn the diseased leaves.

2. Spray with weak Bordeaux mixture once in two weeks, beginning at blossoming time. Precede this by a winter spraying with Bordeaux of full strength.

3. In bad cases cut the tree back so as to cause it to throw shoots from the trunk or larger branches, or graft on some healthy wood.

Preventive Measures.

4. Do not buy trees except under guarantee that they are perfectly healthy. *Nurserymen should be very careful not to take scions from peach-trees that have shown the disease.* If this measure could be enforced there would be very little of this disease.

3. Peach Rust.

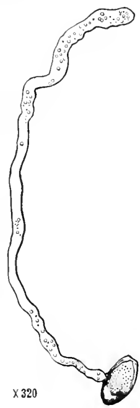
Rust is the very common disease that in the autumn attacks the leaves of peach, plum, and apricot trees, but especially those of the peach. As a result the leaves turn yellow and fall off sooner than they otherwise would, and

Fig. 39.—Germinating spore of the peach-rust fungus, *Puccinia pruni*, Persoon.

Uredo stage.—The yellowish or brownish ovate to pyriform finely echinulate uredospores are borne on pediceles among numerous transparent capitate paraphyses in round and raised pulverulent light-brown sori, which occur in crowded groups on the under surface of the leaves and young twigs of the host-plant, generally giving rise to a yellow discolouration. The apex of the spore is recognized at once by its darker colour and thicker wall. The pediceles are about twice as long as the spores. On germinating each spore displays three germ pores, but gives rise, however, to only one hypha. Germinating spores average 16 x 37 μ, but vary from 12 x 42 to 17 x 22. The sori measure three-tenths of a millimetre in diameter, but several may run together, giving rise to larger compound sori. On the fruit of the peach the sori are commonly small (punctate) and scattered.

Puccinia stage.—The pedicellate teleutospores, measuring 17 x 31μ. are composed of two nearly spherical cells—a larger terminal dark-brown cell, and a smaller basal cell of a lighter hue—both being flattened at the point of union, and both presenting numerous short but stout spines. The pediceles are of about the same length as the spores. The cell walls are of uniform thickness. The dark brown or black round pulverulent sori are situated as in the case of the uredo sori, and measure one-fourth of a millimetre in diameter.

Hab.—Leaves, young branches, and fruit of the peach, where it gives rise to much trouble, causing the leaves to be shed prematurely, thus diminishing the vitality of the tree, as well as giving the fruit an unsightly appearance. This species is the *Uromyces amygdali* of Cooke, of which original specimens have been presented to the Department by Mr. Bailey, the Government Botanist, Queensland. We do not see that it differs in any marked way from *P. pruni*, Pers., and in the absence of any cultivation experiments must regard the two as identical. The spores are devoured by the larva of a species of *Diplosis*.



the growth of the tree is impeded. The appearance of the disease need hardly be described to owners of peach-trees, it is so very common. Suffice it to say that the rust is due to a fungus belonging to the same family as the common and notorious wheat rust, that it occurs abundantly on the lower side of the leaves in the shape of small pustules, each of which gives

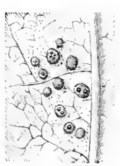


Fig. 40.-Portion of a peach leaf near the mid-rib as seen under a magnifying-glass. Pustules, due to the peach-rust fungus, are shown, and, growing in the midst of them, the dark pycnidia that give rise to the two-celled spores shown in Fig. 44.

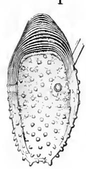


Fig. 41.—Spore of the peach-rust fungus magnified more than in Fig. 39.

Fig. 42.—Teleutospores of the rust-fungus found attacking the leaves of the plum-tree.

rise to a brownish powder, which, when examined with a microscope, is found to be composed of bodies shaped like those shown in Figs. 39 and 41.

I have made in connection with the fungus causing this disease a number of observations that are of some considerable interest from a scientific point

of view. The uredospores of the disease (the teleutospores are rare on peach-trees in this Colony) can be made to germinate very readily in water in a moist chamber. When so germinating their usual appearance is shown in Figs. 39 and 41. On one occasion, however, I observed an apparent amalgamation of the promycelium of three adjacent spores.

Fig. 43. — Three uredospores of the peach-rust fungus, whose mycelia, germinating in water, have amalgamated.

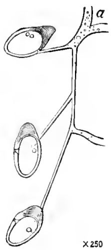
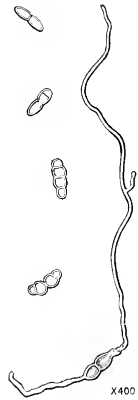


Fig. 44.—Conidia that arise from the minute black pycnidia shown as growing in the rust-pustules of peach in Fig. 40. The upper spore is shown as it issued from the pycnidium, the next lower has begun to germinate. The next two show further stages of the germination, which takes place somewhat after the manner of the growth of the yeast plant. The lower figure, however, shows one of these same spores producing a well-developed mycelium.



The appearances are faithfully shown in Fig. 43. The only doubt that can possibly arise is that the hyphæ became entwined and thus deceived me, but I hardly think this can have been the case. Again, I frequently find among the uredospores of

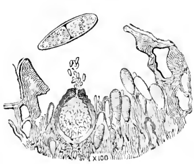


Fig. 45.

Fig. 45.—Small black pycnidium growing among the uredospores of the rust of acacia. One of the two-celled conidia arising from this pycnidium is shown above more highly magnified. This rust may be described as follows:—

Melampsora phyllodiorum, B. and Br. *Uredo* stage.—The round uredo sori, which are only two to three-tenths of a millimetre in diameter, occur on both surfaces of the leaves of the host-plant, and are usually crowded together in large numbers, and then cause wart-like growths of a dark brown colour. The thickening of the leaf under the sori is due to increase in the tissues. The yellowish brown obovate-elongate uredospores are borne on pedicels nearly twice as long as themselves, and are unaccompanied by paraphyses. The spore-wall is moderately thick, and its surface is marked with short obtuse echinulæ or warts, arranged in longitudinal and transverse rows like the grains on a cob of maize. The internal cavity, especially of the transparent young spores, which are as usual larger in proportion to the width than mature spores, is somewhat cylindrical—that is, is truncate at the ends, especially so at the apex. The mycelium averages only 2 μ. in diameter. Each mature spore is possessed of four equatorial germpores, and has, on the average, the dimensions 17 x 41 μ.

As the uredospores fall away a pycnidium appears in their place, apparently from the same mycelium that produced the uredospores, at all events in the centre of the same sorus. These pycnidia are nearly spherical, and have a small ostiole around which the peridium is nearly black. We have seen this growth repeatedly, and have examined it closely by means of very carefully made sections, and believe it to be normal. The connection with the uredospore sorus is so intimate that it is difficult to form any other opinion than that the uredospores and perithecia originate from the same mycelium.

Puccinia stage.—I have not seen the teleutospores.

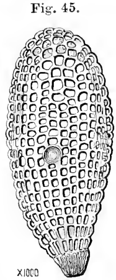


Fig. 46.—Spore from the pustule shown on Fig. 45, very much more enlarged.

a pustule of this rust small black pycnidia producing a multitude of two-celled spores, which, when placed in a moist chamber, often bud and multiply after the manner of yeast plants, but which occasionally produce a mycelium. Further, I find in the pustules of a number of Australian rusts similar tiny black pycnidia, producing similar two-celled spores which behave in

precisely the same manner. Among other rusts producing these bodies is that occuring on acacias, and that which occurs on a species of *Agropyron*, probably the species *scabrum*. There are, *a priori*, two ways of accounting for these pycnidia: either—1, they are parasites on the rust; or, 2, they are an integral part of the rust, and represent another spore-form of the rust.

This is such an interesting subject that I have often wished to inquire into it carefully but have not done so, solely for lack of time. Perhaps someone more fortunately situated will undertake the task. These two-celled bodies have, as I have on several occasions publicly remarked, no slight resemblance to the so-called spermogonia of several species of Aecidium, and this idea has already been fruitful of considerable discussion. Do not the various bodies that have in this connection been called spermogonia and spermatia need a more careful examination than they have yet received?

As I before remarked, the teleutospores of the stone-fruit rust (or rusts) are not common on peach-leaves in Australia. I have noticed that when peach-trees grow in close juxtaposition to plum-trees the teleutospores are not uncommon on the peach-leaves as well as on those of the plum. This certainly suggests that there are either two species of rust occurring on the peach or that there are at least two distinct forms, whether or not they be regarded as distinct species. This observation is entirely in accord with the conclusions of a number of observers who have during recent years given close attention to the forms and physiological characters of a number of other common rusts. The form of the teleutospores growing on plum leaves is shown in Fig. 42.

Fig. 47.—Sprig of peach attacked by the well-known shot-hole fungus.

4. Shot-hole.

This disease is one that is very common on the apricot, both on the leaves and on the fruit, some observers to the contrary on this latter point notwithstanding. In Australia, at least, whenever the leaves of apricot-trees are badly riddled by this disease, the fruit rarely escapes injury. One side of the fruit becomes scabby from the attacks of the same fungus that attacks the leaves; and often when the fruit is attacked in a young stage it is ruined, as it fails to grow on one side, and does not make much progress on the other. As to

the nature of the fungus that causes the disease, it has been carefully set forth, more especially in drawings, in previous reports, to which I have had little to add in recent letters except that I have since seen much worse cases on peach-trees than I had supposed possible. The injury on the peach-tree seems, however, to be largely confined to the leaves. (See Fig. 47.)

Remedies.

Spraying with ammonio-carbonate of copper, or weak Bordeaux mixture, has proved a pronounced success wherever it has been carefully tried. The full details have already been published in this Journal, and they need not be repeated here. (See Vol. III, p. 289.)

5. The Crease in Peaches.

I have noted a number of varieties of peaches, more especially late varieties, which have a crease so deep as to be a decided defect. This deep crease harbours both fungi and insects, whose ravages sooner or later cause the peach to decay. This defect in peaches is as bad as the open channel that exists in some varieties of apples, leading from the eye of the apple to the core, and bad for precisely the same reason.

VII. Gall-worm.

Six years ago, when this Journal was first founded, I had the honor and the sorrow to announce the presence in this Colony of the notorious gall-worm *Tylenchus* (or *Heterodera*) *radicicola*, Greef., an insidious and destructive pest, inhabiting the soil, and attacking the roots of a great variety of plants, and causing damage in many respects comparable with that produced by phylloxera. Since that time I have found that this worm occurs in at least all the Australian colonies except Tasmania. Having examined specimens from various parts of these Colonies, I am in a position to say that it is on the high road to occupancy of the whole continent. Its ravages are so hidden from sight and of so strange, and to the ordinary mind, of such inexplicable a nature, that it is, beyond question, already doing even greater harm than can be demonstrated by evidence. But when I say that I have collected, or received, specimens of the disease from a chain of localities extending from Bundaberg, in Queensland, to Adelaide, South Australia, I think I am making a sufficiently alarming statement.

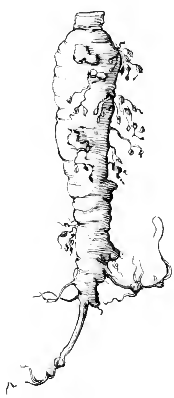


Fig. 48.—Parsnip attacked and deformed by root-galls.

Inasmuch as the original article on this subject is now out of print, I think it best to insert here a repetition of that part of the article that deals with the measures that may be adopted to hinder the progress of the disease. I am sorry to be unable to hold out any hope that the disease can be anything more than hindered, which is the saddest statement I have to make in all this long tale of disease and loss. Those who have their land

already so badly infested as to be almost unable to grow a decent crop of any sort will, I fear, be the only ones who will realise the full force of my words.

The nature of the disease caused by the gall-worm will become clear as soon as the diseased tissues are carefully examined. Fig. 49 represents a portion of a diseased parsnip rootlet, considerably magnified. The two swellings have been caused by, and contain, the gall-worms. Between the swellings the rootlet retains its normal size and structure, except that some modification may occur through sympathy with the diseased part. If a thin section of the undiseased part be examined, it will be found to present the usual structure. Beneath the epidermis of the rootlet lie cells constituting the hypoderm, and in the midst of these is found a single large central vascular bundle surrounded by pericambium. The tissue of the central vascular bundle is made up of three portions,—the woody portion or xylom, having in the section the contour of an hour-glass or dumb-bell; the sieve tissue or phlöem, appearing in the section as two narrow crescent-shaped areas, lying between the two parts of the xylom and the surrounding pericambium; the cambium occupying the remaining space, *i.e.*, the two angles where the two xylom portions come into contact near the centre of the rootlet. If now a section of the diseased part of the same rootlet be examined, it will be found that the additional size is caused by an increase in the amount of each tissue, but particularly of those constituting the vascular bundle. The epidermis and hypoderm remain comparatively unaltered in structure, but have increased somewhat in amount. The central vascular tissue, on the other hand, is much altered. It is increased in quantity, and the vessels have become much distorted. Instead of continuing parallel to the axis of the rootlet, as they would normally do, the vessels have become twisted about, and are often found turned to one side or the other, passing sometimes in a radial direction, and even in some cases turning backward. Whatever portion of the tissue has been actually invaded by the worm is easily recognised by its yellow colour. In the majority of cases, according to my observations, it is the cambium of the rootlet that suffers the greatest destruction.

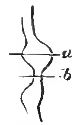


Fig. 49.—Portion of a rootlet of parsnip showing two galls, due to the attack of gall-worms. Magnified from Fig. 48.

The rootlets are the most fundamental organs of a land-plant. Upon them depends its supply of water and earthy material. Taking this fact into consideration, we shall no longer wonder after noting the changes wrought by the gall-worm, why so small an assailant can do so great injury. The plant is attacked at its weakest point. The tissues of one of its most essential sets of organs, the rootlets, become aborted. The absolutely essential food due the plant from the soil is cut off, and unable to live upon air alone it dies.

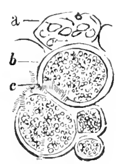


Fig. 50.—Tissue of potato magnified 40 times. *a*, cell containing starch grains; *b*, spherical growths seen in potato attacked by gall-worms; *c*, vesicular tissues.

Let us now turn to the disease as manifested in the potato. Fig. 50 represents more or less spherical growths which appear in the substance of attacked potatoes. These growths seem always to be connected with distorted vascular tissue. They are found to vary much in size, and there seems little doubt that the "knobs," characteristic of the disease as it appears on the potato, are the result of these small beginnings. Each such body is composed of a thick outer wall, and an inner granular mass.

These appearances in the parsnip and potato lead me to suspect that the abnormal growths caused by the gall-worm are probably to be compared to the galls produced on leaves by various insects. It is well known that leaf-galls are caused in the first place by a disturbance of the vascular tissues. The gall-producing insect commonly pierces a vein of the leaf with its ovipositor when depositing its egg. It is a common belief that the gall appears in consequence of a fluid injected by the insect at the time of laying the egg. I do not know whether this belief is supported by any good evidence. Possibly the mere irritation of such a foreign body as the egg of an insect or the wriggling larva hatched from it may be sufficient to account for the growth of the gall.

If I am right in comparing the swellings produced by this nematode to the leaf-galls produced by insects, then the former should be called root-galls, and the nematode itself may appropiately bear the name of the gall-worm. Dr. Neal has called the disease, as it appears in the United States, the root-knot disease. His name can have no referance to knots, the places where branches originate, otherwise it would be entirely inappropiate, but it refers to the characteristic appearance produced by the disease on rootlets which has been compared to the appearence of a thread with *knots* tied in it. The German name for the disease caused by *Tylenchus Schachtii* is Rübenmüdigkeit—that is, turnip-lassitute or beetroot-lassitute, referring to the tardy growth of the diseased plants. I believe both these names will be supplanted by the simple term "root-gall" (Wurzelgalle), which may be thus defined—abnormal growths on roots and rootlets, caused by the attacks of gall-worms.

Historical.

It is not until within recent years that we have arrived at an accurate knowledge of the habits of the gall-worm, although the disease root-gall has been known for a very long time. How long root-gall has been recognised as a distinct disease of the sugar-beet of Europe I am unable to say, but that it is very many years is certain. The root-gall of the peach has, according to Dr. Neal's exceedingly useful pamphlet, been known to the white people of the South Atlantic and Gulf States of America since the earliest settlement of the country; and, according to the same authority, reliable agriculturists state that the disease is indigenous there, they having seen it in places where neither trees nor plants had ever been introduced from other sections. The disease is now known to occur in North America on a belt of land 150 miles wide, extending from Texas along the Gulf of Mexico and Atlantic coast northward to the January isothermal of 50° Fah. According to the best testimony yet obtained, the peach-tree formerly grew on this area with no other disease than the borer, except in damp localities; while now in many places, owing to the prevalence of root-gall, the trees that do well are the exception. This fact shows how the disease has spread, or at least increased, and should serve as a warning to Australians.

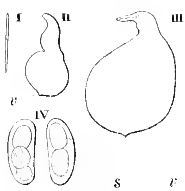


Fig. 51.—Gall-worms, taken in different stages, from the interior of a potato. I, young worm; II, female becoming gravid; III, full-grown fertile female; IV, eggs in two first stages of segmentation; *v*, vulva. I, II, and III are magnified 25 times; IV is magnified 100 times.

In the United States the plants that have been found to be attacked by *Tylenchus arenarius* of Neal, which is the same as the Australian worm, are as follows :—

Badly affected.—Roots of cabbage, kale, potato, banana, radish, okra, pea, peanut, cow-pea, bean, squash, pumpkin, melon, cucumber, tomato, beet, plum, apricot, peach, almond, fig, English walnut, willow, gourd, bigonia, sunflower, amaranth, dahlia, koniga, iberis, coleus, achyranthes, purslane, sand-purslane, verbesina, worm-wood, Jerusalem-oak.

Slightly affected.—Roots of cotton, egg-plant, pepper, spinach, cassava, maize, orange, grape, mulberry, walnut, pecan, hibiscus, ice-plant, parlor ivy, morning-glory, nolana, petunia, boussingaultia, spirea, flowering almond, buddleia, cape jessamine, shepherd's purse, blackberry, dewberry, eupatorium, cypress vine.

These lists include the majority of the most useful food-plants, many ornamental plants, and a number of the commonest weeds. Among the latter, the roots of purslane, amaranth, Jerusalem-oak, and worm-wood harbour the greatest number of worms.

The extent of the damage done by gall-worms is difficult to estimate. Much land in Europe has become so badly infested that certain crops—for example, sugar-beet—have had to be abandoned altogether. Not a beet-root will mature. The plants break the ground, languish a few weeks, and then die. Since time immemorial, crops of various kinds have died suddenly—so suddenly, Dr. Neal remarks, as to justify the expression, "struck by lightning." The unknown cause in some such cases has probably been the gall-worm. Many an agricultural or horticultural failure attributed to the use of improper fertiliser, to poor soil, or wrong cultivation, has been due to this insidious foe attacking the very fountain-head of vegetation. Were it possible to sum up in pounds, shillings, and pence the damage done by gall-worms, the total would probably amount to a fortune for a nation.

Remedies.

All that can be done in combating root-gall must be directed toward prevention. Once the gall-worm gains access to the roots, the game is up. A leaf-destroying pest may be dealt with even after its attack has made some progress, but thus far, at least, roots and rootlets are largely inaccessible except at the expense of the life of the plant. Hence it follows that all rational remedies for root-gall must be directed either toward ridding the soil of the gall-worms, or toward putting such obstacles in their way, or so reducing their number, as to render their ravages bearable. These ends have been sought in various ways.

1. By the use of some chemical, preferably a fertilizer, which will destroy the free-living larvæ.
2. By the selection of varieties not subject to root-gall.
3. By trapping the worms and thus removing them mechanically from the soil.

I shall consider the last of these methods first.

1. *Trapping.*—It consists in actually capturing the worms and then killing them by hand or by machinery. How to capture a foe numbering millions and doubly masked by being invisible and being hidden away underground might well seem a puzzling question. How it was answered constitutes one of the interesting passages in the history of applied science. The gall-worm of the sugar-beet had long been known to be one of the worst pests of that crop. Various investigations were made and various remedies tried by those

interested in the sugar-beet industry, but to little purpose. Year by year the pest grew worse,—more and more land had annually to be abandoned by the beet-grower. At this point the philosophical faculty of the University at Leipzig offered a prize for the best investigation of the cause of the Rübenmüdigkeit. The prize was awarded to Strubell for an investigation whose results are detailed on page 170, Vol. I of the *Agricultural Gazette* of N.S.W., under the head of *T. schachtii.*

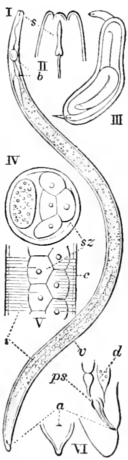


Fig. 52.—Male gall-worm. I, mature male, x 65; II, head of same, x 450; III, larval male, inside of its cast off skin, x 50; IV and V, cross and longitudinal sections, x 350; VI, lateral and ventral view of tail, x 225; *s*, spear; *b*, bulbs; *i*, intestine; *s z*, spermatozoa; *c*, cuticula; *v*, vas deferens; *d*, end of ejaculatory duct; *ps*, penes or spicula; *a*, anus.

Professor Kühn, making Strubell's investigations the basis of his reasoning, now devised a plan for trapping the larvæ. Noting that, according to Strubell's investigations, the larvæ on entering the young beet plant became mature in about five or six weeks, he predicted that if the plants were pulled at the end of four weeks, the worms in them would die without producing a new brood. It will be seen that Professor Kühn's plan was based on a careful perusal of the life-history of the *Tylenchus.* If the plant should be allowed to remain five weeks before being pulled, the *worms* would, it is true, be killed, but *not so the eggs which in five weeks the females would have produced.* These eggs would ultimately hatch and the pest continue. But after precisely four weeks, even the oldest worms in the roots would not yet have produced eggs, and, being at that time motionless sacs, incapable of boring their way out, must perish from starvation if the host-plant should suddenly die. In other words, Kühn proposed to make traps of the young plants, and naturally chose such plants as are loved best by the worms. Sugar-beet was selected as the plant likely to entrap the greatest numbers.

The result of the experiments based upon Kühn's plans was a brilliant one. A piece of ground, so badly infested as to be useless to the sugar-beet grower, was sown with sugar-beet. After four weeks the plants were pulled, and another lot of seed sown. The experiment was repeated a third time, if necessary, and it was then found that the pest was controlled. The time occupied was about three months. The plants whose roots were used as traps could be turned to account as fodder or fertiliser, so that the twelve weeks were not a dead loss. In Kühn's first experiments the plants were pulled by hand. That operation was expensive, and led to a trial of ploughing up the trap-roots, and this plan was found to answer almost equally as well.

It is beforehand to be supposed that the Australian gall-worm may be trapped in the same way as *T. schachtii*, but the time required for its development is not yet accurately known. I have no data for giving the *precise* length of time required for the larvæ to mature in roots. The most I can say is that it is probably less than that required by the sugar-beet gall-worm.

Consequently, in any trial of Kühn's remedy in dealing with the Australian gall-worm, it will be best, in the present state of our knowledge, to keep well within his limits and allow (say) three weeks before ploughing up the trap-roots. Mangels will make the best trap-root, and they should be sown thickly. Cow peas may also be tried.

2. *Gall-proof Varieties.*—Dr. Neal recommends, as a practically gall-proof stock for the orange, the hardy bitter-sweet or sour species, and, with some qualification, Citrus trifoliata, and the Japanese Unshin, or Satsuma; as a nearly gall-proof stock for the peach, seedling American wild plum or one of the Japanese plums Kelsey, Satsuma, or Ogru; as a stock for grapes perhaps the *cordifolia* or *vulpina* races. For other plants subject to root-gall he found no resistant stocks.

Fire is a powerful destructive agent which may, in certain cases, be brought into play in combating root-gall. The larvæ of the gall-worm infest the soil to a depth of at least 2 feet, but by far the greater number are

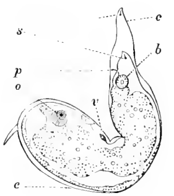


Fig. 53.—Moulting larva of a gall-worm, x 100; *c*, old skin; *s*, spear; *v*, ventral gland that emptied through the pore *p*; *b*, median bulb; *o*, rudimentary sexual organ.

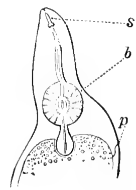


Fig. 54.—Neck and head of a gall-worm, x 200; *s*, spear; *b*, median bulb; *p*, excretory pore.

found within a few inches of the surface. The heat of a large fire will penetrate to this depth in sufficient degree to destroy life. This fact may be applied in setting out those trees particularly subject to root-gall, such as the peach, apricot, almond, plum, and fig. Nothing short of a large fire lasting several hours, will kill the worms. The tree must be set in the midst of the burnt area, and no soil or fertilizer used except such as is known to be free from gall-worms.

3. *Use of destructive chemicals.*—Experiments looking towards the use of some fertiliser or chemical destructive to gall-worms have been made, and the results may be summed up as on the whole negative. No thorough-going chemical remedy for Rübenmüdigkeit has ever been discovered, although multitudes have been tried. Similar negative results were obtained by Dr. Neal in the case of his *T. arenarius*. Still the results are interesting, as pointing out what positively will not succeed; furthermore, they may be made the basis of plans for further trials.

Of all the vermicides yet tried, lime receives the highest commendation. It must be used in large quantities to be effective. (The same is true of the muriates and sulphates of potash and ammonium.) One to two tons of lime to the acre, applied, not all at once, but part in June and the remainder in October or November, may be recommended. The result is the destruction of a large number of worms; but many eggs, protected by the tissues in which they are being incubated, doubtless escape destruction, and live to propagate the disease. I have noticed that when the disease is combated with

chemicals, the method has been in all cases drastic, the attempt being to kill all the worms at one fell swoop. Possibly a homœopathic treatment would be more fatal. It is easy to believe that many of the experiments which have been tried were in reality effective so far as they went, although pronounced unsuccessful because the disease reappeared. My experiments have already shown that the period occupied by the development of the egg of Australian gall-worm may possibly extend over two months or more. While yet in the egg, the young worm is protected by the shell; and this protection is a good one. The shells of nematode eggs (as well as the skin of the larva when it is being cast) are comparatively impenetrable. Poisons which would at other stages of life be fatal, can therefore be withstood by embryos and moulting larvæ. I may support these statements, which are based on my own observations and experiments,* by the remark that the eggs develop in the very midst of decaying matter. The roots attacked by the disease die and decay, thus giving rise to chemicals of considerable strength and activity. Yet the eggs develop unharmed—quite likely, on account of the impenetrability of their shells. Now, suppose in some of the numerous experiments that have been made, all or most of the larvæ actually in the soil and unprotected were killed by the poison used. It is plain that the remedy was a good one, thus far; yet, if the eggs and moulting larvæ escaped destruction, because protected by their coverings, they would give rise to galls in the course of a few weeks or months, and the experiment would be pronounced a failure. I therefore repeat my suggestion that perhaps a more gradual and longer-continued treatment would be successful with some of the chemicals already tried and pronounced ineffective. Among those tried are kerosene emulsion; various solutions of arsenic; bisulphide of carbon; carbolic acid; the sulphates of ammonium, potash and iron; the sulphite, sulphide, and muriate of potash; hyposulphite of soda; tobacco dust.

4. *Frost.*—Dr. Neal says that if in places where the soil is frozen to some little depth each year the ground be ploughed at times during the cold season, it is reasonable to suppose that great destruction of the gall-worms will ensue. I know of no experiments demonstrating that the worms will not revive from the effects of low temperature, as they certainly will from those of long continued dryness.

5. *Drainage.*—It has long been known that drainage has an important bearing on the spread of *T. devastatrix*. Currents of water on or beneath the surface of the soil will pick up and transport small and light objects. Those objects of least specific gravity are most subject to the transporting power of water. Of all the constituents of the soil, none probably are more likely to be thus moved from place to place than minute organisms such as the eggs and larvæ of gall-worms; hence the great importance of drainage in connection with root-gall, as well as with the ravages of *T. devastatrix*. By a good system of surface drainage, surface-water may be so controlled as to spread the disease as little as possible. It is needless to go into particulars, as any farmer can easily devise a system of drains suited to his individual case. This matter must not, however, be overlooked by anyone whose land is infested. It is certain that water is one of the chief agents in the spread of root-gall.

6. *Famine.*—Famine is as destructive to gall-worms as to other animals, and there is not the slightest doubt that land kept quite clear of vegetation will, in time, become disinfected—the worms dying of starvation. How long a time would be required is unknown; probably more than a year. It is not

* For instance, I have observed that species which under ordinary circumstances are instantly killed by osmic acid may withstand the acid for an hour when moulting.

likely that land will be given up for such a length of time, especially when it is remembered that it must be kept clear of vegetation at considerable expense; but the fact that the worms may be starved out utterly, leads to the question whether or not, by a proper rotation of crops, they may not become so reduced by partial starvation as to become comparatively harmless.

The gall-worm evil, like most evils, is endurable so long as it does not become too great. It is only when the soil swarms with larvæ that serious damage is effected. Now, certain crops—for instance, maize and the cereals generally—are but little affected by root-gall. If land badly infested be planted with maize, it is reasonable to suppose that the effect will be much the same as if it stood idle and bare; but it is impossible as yet to say what value this method may have. Of course, this plan contemplates keeping the land absolutely free of weeds while it is bearing maize. The tough root of maize is not easily penetrated by the worms, and, finding no other plant to feed upon, they must, it would seem, of necessity starve.

7. *Use of non-infected Soil.*—When trees are to be set in infected land they may be filled in with earth taken from a depth of at least 2 feet. Such earth is practically free from gall-worms, and, if mixed with some artificial fertiliser known to be also free from them, will be found to answer the purpose well. This is a method recommended by Dr. Neal, though he cautions the gardener to beware using too much nitrogenous fertiliser, saying the vigorous growth thereby promoted is unusually subject to root-gall, because the root tissues are tender and therefore easily penetrated by the worms.

8. *Artificial Barriers.*—Another precaution which is of service in protecting young trees from root-gall is the use of artificial subterranean barriers. Having sterilised a spot of ground for a tree by means of fire, or by the substitution of uninfected subsoil, it becomes a question whether this now uninfested spot cannot in future be kept free from gall-worms, even though the surrounding land be infested. A means towards this end is the placing in the soil of a barrier or obstruction all around each tree, at a distance of (say) 2 feet from it. The barrier may be of staves placed close together in a circle, or, better, of old scraps of iron, such as old kerosene tins or old galvanised sheet-iron. Bark is an excellent and cheap material for the purpose. The barrier should be vertical, or slope from the tree so as to leave room for unobstructed root-growth. The purpose of such a barrier is evident at once. It prevents to a certain extent the entrance of worms from the outside infested soil. It will be effective in proportion as it is tight. Staves would therefore be less effective than old tin or iron in moderately large pieces. The latter, however, are much less likely to be at hand in sufficient quantity. Bark is probably about as available as any material. The pieces of bark should overlap each other. Of whatever material the barrier is made it should extend from a little above the surface of the soil downward at least 18 inches—better, 2 feet. Such an obstruction will, even if made of wood or bark, which will decay in the course of a few years, protect the young tree until it has attained considerable size and sent its roots deep into the ground. After that it is comparatively safe. Old trees with tough roots sinking deep into the ground suffer but little from the gall-worm.

Of course these barriers, even if watertight, will not prevent the entrance of the gall-worms spattered into the enclosed area during rains, or blown in as dust in dry weather. This fact points towards the usefulness of a mulch (uninfested, of course).

How does the root-gall spread, and at what rate? The disease will spread from a centre of infection at the rate of a few rods each year. In such

cases its progress is through the soil, and may be marked by its effects on roots. But infection does not always occur in this manner. During a spell of dry weather the eggs and dried up larvæ exposed on the surface of cultivated ground may be whirled aloft by the wind and scattered for miles over adjacent territory. The disease may thus unseen spread by leaps, making itself felt however in the new localities only after some years have elapsed, and the worms have become abundant by natural increase from the few eggs or larvæ deposited by the wind. These facts indicate sufficiently the rate at which root-gall may spread. The facts and rate are much the same as for *T. devastatrix.*

The different modes by which the disease may pass from one piece of land to another deserve careful consideration, for upon them are based a number of useful precautions. Some of these modes have already been mentioned incidentally, but the importance of the subject will justify dwelling upon them at greater length, even at the risk of some repetition. The migrations due to the animal's own muscular powers are not rapid or great. In fact they are so slight that I think it may be questionable whether they would account for any but the very slowest spread of the disease. Even when the worms pass from plant to plant in the same paddock it is questionable whether the movement is not due to transportation by some of the numerous agencies constantly at work in their neighbourhood. Almost everything that moves either in or upon the soil may transport the minute eggs and larvæ of gall-worms. Air, water, animals are all agents in disseminating the disease. The manner in which winds may act has already been alluded to, and some precautions, such as mulching, suggested. Under the head of drainage we have seen how necessary it is in combating root-gall to have an eye to the surface currents which during rains may pick the disease up as it were, and deposit it in mass elsewhere. The action of subterranean water has also been lightly touched upon. The general lay of the land determines largely the nature and direction of the currents in the soil. These doubtless have something to do with the spread of the disease. Here very little can be suggested beyond a proper system of drainage.

One set of agencies in the spread of root-gall, and a most important one too, has not yet received consideration. I refer to other animals. Insects, earth-worms, birds, domestic animals, man himself, are all factors in the life history of the gall-worm. Let the farmer who is fresh from cultivating his infested paddock show me his boot, and the chances are that I shall be able to remove from it small clumps of earth containing larvæ of the gall-worm. The hoofs of his horses are in a similar condition. If the weather is damp, it only needs a gun to demonstrate that even the feet of the magpie that followed the plough repeat on a smaller scale the same conditions. The insect that burrows in the ground and brings to the surface subterranean material is active in aiding the gall-worm in finding new pastures. The egg or larva leaves the mandibles of the insect only to be seized up by the wind, or be pressed with other matter into some crevice in boot or hoof, and thus, it may be, travel miles before being again set down. This is far from being a fancy sketch; every statement rests on the most unimpeachable observation. Even the hands when soiled from field work may carry enough material to start a thriving colony of gall-worms. It only needs to be washed off, and thrown with the water around roots of some favourite plant (to help it along, poor thing!), to form a nucleus for a new infested area. But enough has been said on this head to put those interested on their guard. The thorough cleansing of boots and hoofs before passing from infested to uninfested land is too obvious a precaution to need mentioning. There could be no more

appropriate closing statement to this section than that of the general principle that whatever moves and comes into contact with the eggs and larvæ of gall-worms is likely to afford them the means of finding new victims.

In addition to the foregoing, *I would caution agriculturists, seedsmen, and nurserymen against rearing, buying, or selling trees, plants, or tubers which show any swelling on the roots, except such as are well known to be natural to them.* I know of a case where this worm was introduced in seed potatoes, and I am confident that this is one of the common ways that this pest travels *en masse* from one district to another. Picture some poor fellow struggling to make for himself and a family a living out of the land. Deciding to try potatoes, he unknowingly secures a lot of seed infested with the gall-worm. Bear in mind that it is not uncommon for a potato to contain more than ten

Fig. 55.—A potato deformed by gall-worms. All the numerous lumps on the surface of the potato are caused by the gall-worms. This potato contained on a moderate estimate at least 10,000 eggs and worms.

thousand worms. Look at this ugly specimen! Every knob on its surface contains hundreds of worms! These he unsuspectingly plants, and (woe is he!) his land is permanently infested. After that, almost any crop he may try to raise will be more or less handicapped, and possibly ruined, as I have seen, and others can testify. *Closely scrutinise the roots of all the plants or trees you buy, and unhesitatingly refuse any that show galls.*

VIII. Diseases of the Grape.

Oidium is a disease well known to attack grapes at a time when they are as large as small marbles. That it may in some cases attack the fruit soon after it sets is not so well known. The accompanying figure shows a bunch of some grapes that set late, and so far as I could make out, were blighted at an early stage by oïdium. There had been no climatic or other known hindrance to

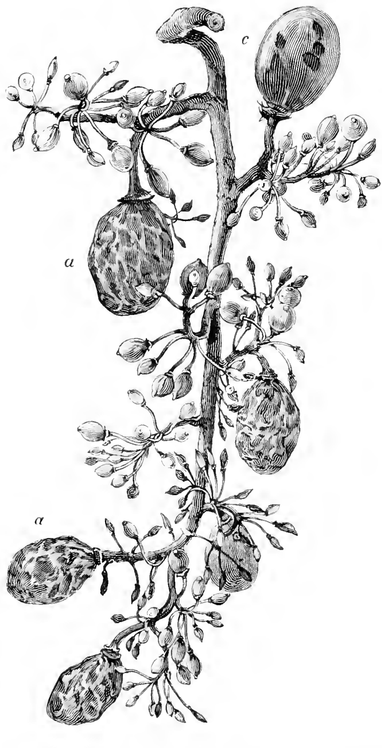


Fig. 56.—Bunch of grapes attacked by the disease oïdium. *a*, Berries with skin shrivelled by the disease; *b*, small berries also attacked by the disease; *c*, a berry still comparatively healthy.

development, and, moreover, the smaller berries were attacked by the fungus. This observation leads one to question whether we begin early enough in the season to apply our flowers of sulphur, the well known remedy for this disease.

IX. Disease of the Onion.

The flower cluster of the common onion is subject to the attacks of a disease that, though not identical with the black-rot of the tomato, is, at any rate, caused by a fungus nearly related to that causing black-rot—so similar that

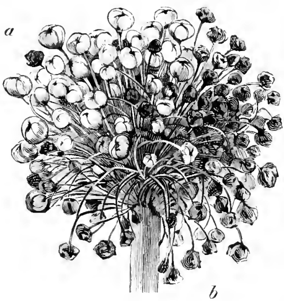


Fig. 57.—A disease found attacking the inflorescence of the onion. *a*, Healthy flowers; *b*, diseased and dead flowers. This disease shows itself by blackening and shrivelling the flowers so that they do not set. The cause of the trouble is a fungus similar in appearance to that causing the well-known black-rot of the tomato. The spores of the fungus are shown in Fig. 58. There appears to be two species here concerned, though but one is abundant.

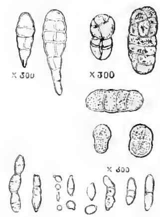


Fig. 58.—Spores of the fungus causing the onion disease shown in Fig. 57. The two upper left-hand spores are of a second species. The remainder appear to be those of *Cladosporium herbarum*.

I have felt justified in recommending remedial measures of a nature similar to those adopted for this latter disease. See Vol. V, p. 386. The nature of the onion disease is set forth graphically in the illustrations.

X. Timber Diseases.

Every year brings me a number of inquiries as to the cause of the death of the whole or parts of trees, generally fruit-trees, under peculiar circumstances, such as the absence of any apparent cause, or, at least, adequate cause. Sometimes the deaths are sudden, sometimes not; but in most such cases the disease has not been prolonged. These cases must not be confounded with death from lack of nourishment or care, or from old age. A tree in good soil, and hitherto vigorous, suddenly sickens and dies, or perhaps manages to hold out for a season or two and then dies; such is the typical case to which I refer.

In such instances we at once suspect one of two causes, namely, insects boring in the wood, or the presence of some timber-rotting fungus.

In the former case the death of the tree or branch is often sudden. The leaves wilt, dry up, and turn brown, as if a fire had scorched them, the whole operation sometimes occupying only a few days. If a limb be cut away and split up, the boring insects are usually disclosed. Their holes may also usually be seen on the surface. (See Fig. 59, front tree.)

In the second case the death of the tree is usually slower, and the cause is commonly more hidden from sight. The wood of the dead tree, however, on being examined carefully, or compared with healthy wood of the same kind, exhibits the peculiarities well known to timber merchants and carpenters under the name of *dry-rot*. The diseased wood is softer and more brittle than sound wood, and differs also in colour, and finally becomes punk and falls to pieces. This deterioration is due to the presence among the fibres of the wood of the hyphæ or vegetative organs of a fungus whose fruit may sometimes be seen either growing out from the bark in the form of "shelves" or "brackets," or in the form of toad-stools near the base of the tree. Strange as it may seem, the microscopic "roots," as we may almost call the vegetative organs of these fungi, penetrate long distances into the solid wood of the tree, where, by gradually absorbing and changing the substance of the cells of the wood, they weaken it and give rise to the well-known appearance of dry-rot. The death of the whole or part of the tree follows as a matter of course. (See back trees in Fig. 59.)

Both these conditions may occur in the same tree, and it is therefore well to give as clear an idea as possible of the external appearance due to each of these diseases. The illustration opposite (Fig. 59) gives a very good idea indeed of the whole matter. The insect attacking the peach-trees represented is the notorious cherry-tree borer, and is the larva of a night-flying moth, while the trunks of the back trees are represented as attacked by both Polyporus (bracket-fungus) and Agaricus (mushroom). The material for this illustration I obtained through the kindness of Mr. Devlin, of Estella, Wagga Wagga.

Remedies.

1. Trees dead or dying from either of these causes should be burnt. If there is reason to attribute the death to dry-rot fungi, the stump and main roots should also be destroyed by fire and the ground treated with quick-lime.

2. Keep the place free from rotting and decayed timber. Such only forms a nidus, from which spring the spores of the dry-rot fungi.

3. Where timber-rot is prevalent, take the precaution to disinfect with tar the wounds on trees, either those caused accidentally or by pruning. In pruning be careful to use sharp tools, and to use them skilfully, and cut off the limbs close to the trunk or main branch that bears them, the idea being to give the tree a good chance to heal the wound as rapidly as possible. (See Fig. 22, p. 21.)

4. Remove superfluous bark, and whitewash the trunk and main branches. (See p. 27.)

5. Where a wound fails to heal over, and becomes a sore, cut away the wood as directed for *Mal di Goma* of citrus-trees. (See p. 29.)

6. Look out that the drainage is good. This is a most important precaution against timber-destroying fungi. Damp, ill-drained forest is their natural home.

7. As regards the remedies for borers, it is necessary to point out that they are, for the most part, totally different to the preceding ones, directed, as they are, against an insect instead of a fungus. It is when I observe remedies for fungi being applied to trees suffering from borers, and *vice versa*, that I realise how necessary it is to point out the possibility of being deceived as to the nature of diseases through resemblances such as have been described

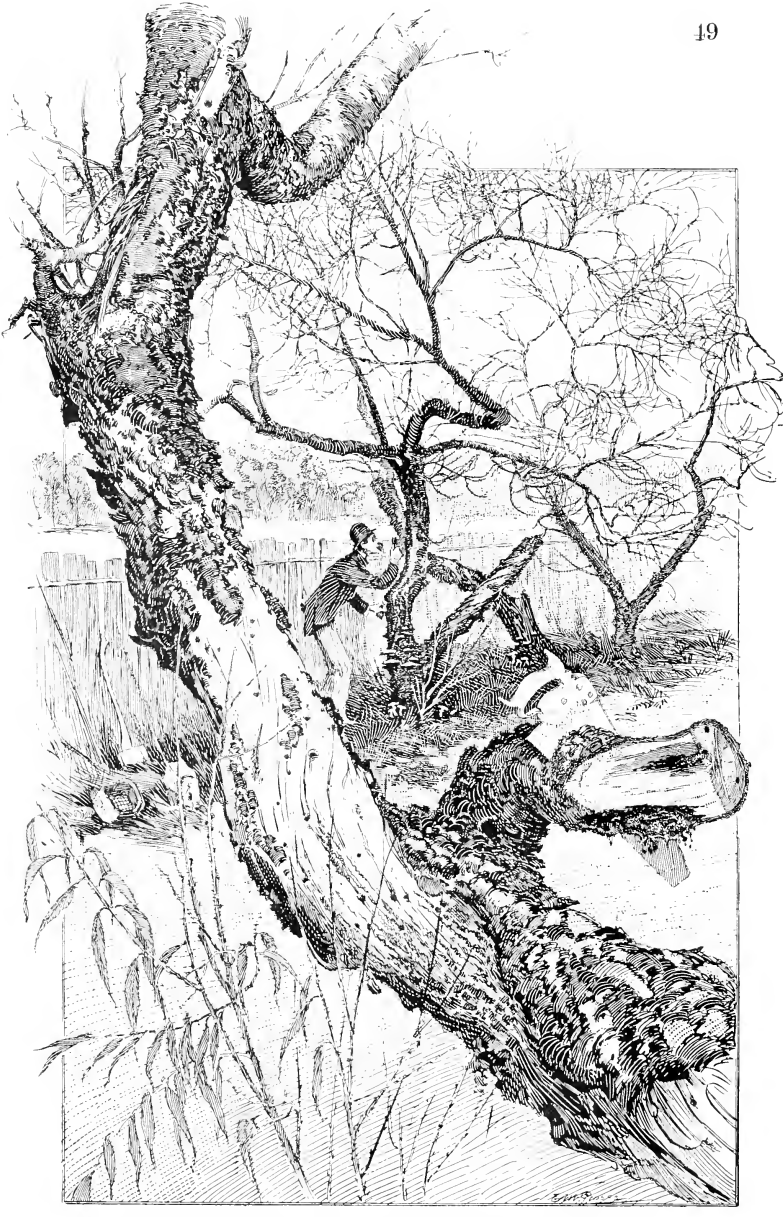


Fig. 59.—Peach trees suffering from the attacks of boring insects (cherry tree borer) and timber-rotting fungi. The front tree has been killed by the borers, whose holes can be seen where the bark has fallen off. The back trees show toadstools and bracket fungi near the base.

in the preceding paragraphs. It is a waste of money and energy to apply the wrong remedies. It would be of little use, for instance, to apply fungicides to trees attacked alone by the cherry-tree borer, as in the case of the front tree in Fig. 59. On the other hand, where the trees are attacked by dry-rot fungi, it would be of little service to—

1. Remove from the vicinity of the orchard, unless they are serving some useful purpose, all sheoak, wattle, and other native trees that harbour the cherry-tree borer.
2. Spray the tree with tar-water, or some other substance that will be so offensive to the female moth that she will decline to lay her eggs there.
3. Remove loose bark, and whitewash the trunk and main branches.
4. Squirt or otherwise insert into all holes and crevices to be found, such liquids as kerosene emulsion or phenyl.
5. Set lighted lanterns at night, in the proper season, and so arranged that the attracted and dazed moths will fly against rags and dangling strings soaked in kerosene, or against some very sticky surface,—

Fig. 60.—*Agaricus melleus*, one of the Mushrooms whose mycelium causes the decay of trees. After Hartig.

for these remedies would be of little or no avail against the dry-rot fungi, although effective as against the cherry-tree borer.

XI. Preparation and Use of the Bordeaux Mixture.

1. Preparation.

Where the Bordeaux mixture is in rather constant use it is a very good plan to keep its two constituent parts in solution, so as to be able to make fresh mixture expeditiously whenever it is required. The following suggestions will be helpful to this end:—

Sulphate of Copper Solution.—Fill a wooden upended cask nearly full of water, putting in (say) 40 gallons of water. Hang in this cask, just under the surface of the water, 8 lb. of sulphate of copper, done up in a piece of sacking. On the morrow the copper sulphate will be found to have dissolved, so that each 5 gallons of the water will contain 1 lb. of copper sulphate. Cover it well, and mark the inside of the cask where the surface of the solution stands, so that if, when the cask is next examined, the solution has somewhat evaporated, the requisite amount of water can be added to make up the deficiency. This is a stock solution to be kept on hand, from which to make mixtures as required.

Whitewash.—If quicklime be kept long in stock it "air-slakes," and this is undesirable, because the whitewash made from partly slaked lime is inferior. Adopt, therefore, the mason's plan of slaking a large bulk of lime and keeping the whitewash in stock. Slake the lime in the usual way while it is still all good, *i.e.*, freshly burned and "quick." Make a rather thick whitewash, of smooth consistency, free from lumps. Store this in an iron tank or large cask. As soon as it is poured in it begins to settle, and in a day or two the top part will be found to be quite clear. If the tank or cask be kept covered this subsided whitewash can be kept a long time, it being only necessary to keep the surface covered with water. Evaporation will take place and the deficiency thus created must be supplied by adding water from time to time. This is the second stock solution from which to make mixtures as required.

With regard to the first of these stock solutions the copper sulphate solution, I would remark that it is a matter of no particular consequence how much copper sulphate is dissolved *so long as the amount is known.* Thus if the orchardist prefers to make a stronger solution by dissolving 40 lb. of copper sulphate in 40 gallons of water, there is not the slightest objection, in fact there is some advantage, inasmuch as the solution will occupy a smaller space for a given quantity of the copper sulphate. The main point is to *know how much by weight of the copper sulphate there is in each gallon* of the stock solution when it is made.

Bordeaux mixture.—To make up a mixture from the two stock solutions proceed as follows: First decide what strength of Bordeaux mixture is to be made. Suppose it is decided to make a mixture that shall contain 3 lb. of copper sulphate to each 40 gallons of mixture, and the stock solution of bluestone contains 1 lb. of bluestone in each gallon of water. Take 3 gallons of the stock solution of bluestone (which of course will contain 3 pounds of the sulphate) and dilute it to about 20 gallons. Stir up the settled whitewash with a paddle until a smooth thin whitewash can be dipped out. Dilute this with water, making sure, however, not to dilute it so much that more than about 10 gallons will be required to combine with or neutralise the 20 gallons of copper sulphate solution. This is something that has to be learned by practice, but it is easily learned. Strain the whitewash if necessary, in order to remove lumps, but it ought

not to be necessary. Now add the whitewash slowly to the sulphate solution until the latter is neutralised, which can easily be ascertained by testing the mixture with a solution of ferrocyanide of potassium, a yellow crystalline salt to be had of any chemist. Buy sixpenny-worth—it will last a long time. Dissolve the sixpenny-worth of ferrocyanide of potassium in a tumbler of water and place it in a bottle. It will keep ; be careful with it, however, as it is very poisonous if taken internally. The solution, if properly made, will be light straw-coloured.

To test the Bordeaux mixture so as to find out when sufficient lime has been added to the 10 gallons of copper sulphate solution, take a drop of the mixture on your finger and daub it on to a board, or better, a bit of white paper, and add a drop of the ferrocyanide solution with a finger of the *other* hand. If you have not added sufficient whitewash, the ferrocyanide will produce at once a red colour. Keep adding whitewash until the ferrocyanide just fails to produce at once or after a few moments a decided red colour. When that point is reached the copper sulphate is exactly saturated or neutralised by the lime of the whitewash. This is a better test than sticking in a knife-blade,—quicker and more decisive, and more accurate.

When the copper sulphate is just saturated you have a choice of adding more lime or not. In my opinion, for most purposes it is desirable to add as much lime again as has been added to secure the above test. But the addition of too much lime is not desirable, because you may by this means so dilute or cover up the copper compound as to render it ineffective.

It will be seen that in saturating the copper sulphate solution with whitewash, it is necessary to keep note of how much whitewash is added. This is done by the use of a quart measure. If no account is kept it will be impossible to tell how much additional whitewash to add.

The knife-blade test referred to above consists in thrusting a clean knife-blade or other piece of polished iron or steel into the mixture that is being made. If a deposit of copper forms on the iron after a minute or two, the sulphate of copper is not yet neutralised, and more whitewash needs to be added. This test is by no means so sure, or quick, or accurate as that with ferrocyanide of potassium, but it has the advantage of being nearly always readily applied.

Should too much whitewash be by accident added, so that on the first trial neither of the above tests (copper on the knife-blade or red colour with the ferrocyanide) can be secured, either of two methods can be followed—

1. Throw the mixture away and start again.
2. Add more copper sulphate solution until a red colour just begins to appear.

In this latter case, however, it will be essential to know just how much extra sulphate solution is added, so as to know how much to make the mixture up to finally.

It will probably be best for the beginner to begin in a small way, and if he overshoots the test, throw the mixture away and try again. All the difficulties (and even these are slight) are in learning how ; once learned, this method of preparing the mixture is as easy as any—in fact, considerably easier.

We will suppose, however, that no accident has occurred, so that the 10 gallons of sulphate solution have been properly neutralised with whitewash, and that then as much again whitewash has been added. It now only remains to add water until the whole mixture is made up to 40 gallons, and we have a properly-made Bordeaux mixture containing in every 40 gallons just 3 lb. of sulphate of copper.

The advantages of this method of preparing the mixture are—

1. Expedition. It is the *quickest way* where the mixture is regularly used and is required from time to time through the season.
2. It is *accurate.* It does away with the uncertainty always connected with the strength of commercial quicklime.
3. It is the most *economical* way. No lime is wasted.
4. The resulting mixture will *always be the same,* and there will be no risk of "burning" the plants by spraying with a mixture too strong, or wasting time applying a mixture that is too weak to do any good. Both these mistakes are too common, and will account for the failures that are from time to time reported to me. Bear in mind that there is no doubt about the efficacy of this mixture in the cases where properly qualified persons recommend it. All the failures, and I am glad to say they are comparatively few, arise from ignorance of how to make or apply the mixture.
5. Finally, the making of the mixture from dilute solutions gives a finer precipitate, which is more easily kept in suspension, and is *less liable to clog* the nozzle. Perhaps this ought to be made a little plainer. I will therefore put it this way: If 1 lb. of sulphate of copper dissolved in *ten* gallons of water be neutralised by 1 lb. of quicklime in *ten* gallons of water, the precipitate will be finer than if 1 lb. of sulphate of copper dissolved in *one* gallon of water be neutralised with 1 lb. of quicklime dissolved in *one* gallon of water,—even though afterwards the latter mixture be made up to 20 gallons, which is the same bulk as the first when finished; and, of course, if the precipitate is finer it will give correspondingly less difficulty in the application.

2. Compound Mixtures.

I now come to the question of mixing two of the different liquids used to combat insects and fungi. This is a matter that brings letters of inquiry from time to time. Suppose, for instance, there is no chemical reason why Bordeaux mixture, a fungicide, and the resin-soda compound, an insecticide, may not be mixed. Suppose, as is actually the case, that when those two liquids are mixed, each retains all its chemical properties, would it not be a saving to mix the two and apply both at once, and thus with one *coup* attack both insect and fungus pests? This is the question that has been propounded to me more than once, and has cropped up also in other parts of the world. This particular question, put by an inquirer, has been answered as follows:—

"You are quite right as to the weakening of each mixture by the other, which could, however, be compensated for by doubling the strength of each. The advisability or otherwise of using the two mixtures together is not yet fully settled by experimenters. To me the probability in this particular case (Bordeaux and resin-soda) seems to be that experiment will show the mixture to be inadvisable, (1) because the Bordeaux will be clotted into a more insoluble state by the resin compound, and (2) because the resin compound (which, as you know, acts partly by "sealing in" the scales and thus smothering them) will be converted into a less perfect varnish by the lime and copper compounds. Two separate sprayings, on the other hand, even supposing them to be different mixtures, will be high in effectiveness

for reasons set forth in the enclosed pamphlet, which has hardly even yet been comprehended by experts themselves.*

"To follow either of these, however, at once by the other will be a less effective way than to use them alternately at intervals of a few days. If you wish to use both on the same day, something must be sacrificed. That sprayed on first will have the best chance of doing good, and hence you must be guided by your particular circumstances; and if the trees are suffering most from insects use the resin compound first, while if they are suffering most from fungi use the Bordeaux first."

This answer is not meant to deny the possibility, or even the probability, that a first-class combined insecticide and fungicide may yet be discovered; it is merely an opinion based on experience with the two mixtures mentioned. It is well known, for instance, that Paris Green, applied to apple-trees, acts both as a fungicide on apple scab and as an insecticide on the codlin moth, and even when mixed with Bordeaux mixture, still retains its poisonous properties in an efficient degree.

XII. Miscellaneous.

1. Drying Fruit for Home Consumption.

Most of the Colonial literature treats the drying of fruit in such a manner as to imply that the application of the fumes of burning sulphur and other chemical treatments are essential and necessary parts of the operation. The following note to an inquirer throws light on a neglected phase of the question:—"I would like to add a few words about drying fruit for home consumption, as I understood you to say that was your object. You will notice in the book I lent you that a good deal is said about sulphuring and dipping in caustic solutions. Both these operations give a sample that markets better because it *looks* better, not because it actually *is* better. In fact both these operations introduce unwholesome elements into the dried fruit, and though it is to be admitted that the quantity is small, still it is there. Therefore, in drying for home consumption, I believe it wiser, and it is certainly cheaper, to omit these operations. A dark colour is not in itself unwholesome, and it cannot be disputed that the flavour of fruit properly dried without either of the above processes is superior to that obtained by their use. This advantage (for home consumption) more than counterbalances any darkness of colour. Drying for the market is different—more's the pity. There you must suit customers or fail in the business."

* Dialogue concerning the manner in which a poisonous spray does its work in preventing or checking blight. 8 pages, with 8 original illustrations in the text. *Agricultural Gazette*, Sydney, 1891.

[One plate.]

Sydney: William Applegate Gullick, Government Printer.—1897.

BY THE SAME AUTHOR

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